# Analysis of routine hospital administrative data (including Hospital Episode Statistics) to assess variation in process and outcomes in gastroenterology

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**Abstract –Analysis of routine hospital administrative data (including Hospital Episode Statistics) to assess variation in process and outcomes in gastroenterology**

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***Background and Aims***

To explore outcomes following gastrointestinal endoscopy using a clinical dataset and then routinely collected administrative data linked to death registry data. Predictors of outcome were studied and variations in crude mortality were analysed.

***Methods***

Endoscopy cases from a single tertiary centre were identified retrospectively using a clinical endoscopy database. Sedation levels, type of procedure and demographic data were analysed. Adverse events following the procedures, including mortality were assessed before and after changes in sedation practice were introduced.

For subsequent chapters national administrative data in the form of Hospital Episode Statistics (HES) were linked to the Office of National Statistics Death Registry. Data from 2006 – 2008 were analysed. Episodes of care containing codes for therapeutic endoscopic procedures were extracted (Endoscopic retrograde cholangio-pancreatography (ERCP) and percutaneous endoscopic gastrostomy (PEG)). Finally, episodes of care containing new stroke diagnoses were extracted to analyse the use of percutaneous gastrostomies in the stroke population in England. Factors associated with death following endoscopy were identified. Crude and case-mix adjusted mortality were analysed at institutional level.

***Results***

7,234 endoscopy cases were identified from the endoscopy clinical database. Following changes in sedation practice 7,071 cases were assessed. Significant reductions in sedation doses were achieved but mortality rates did not fall (0.7% in 2004 and 0.8% in 2006 ($p$=0.5)).

40,938 episodes of care containing ERCP procedures were identified within the HES data. Logistic regression analysis confirmed age, sex, cancer, emergency admission, and non-cancer co-morbidity as independent predictors of 30-day death after ERCP. Adjusted odds ratios for age were 6.2 for ≥85 yrs vs. <55 yrs; male sex 1.2 vs. female; emergency admission 2.0 vs. elective; cancer 8.6 vs. no cancer and non-cancer co-morbidity 1.5 vs. none. Trust volume of ERCP was not found to be a significant factor in post procedure mortality. Funnel plots of trust level mortality rates, both unadjusted and adjusted, showed all trusts lying within 3 standard deviations of the national mean.

10,952 PEG cases were identified. All-cause mortality was 4.2% at 7 days and 14.6% at 30 days. Logistic regression identified age over 85 years, male sex, emergency admission, motor neurone disease and dementia as predictors of death within 30 days of PEG procedure ($p<0.03$ for all). No correlation for 30-day death versus PEG volume was identified at NHS Trust level (Pearson r=0.04).

1560 emergency stroke admissions that had a new PEG procedure were identified. Admission to Trusts with a high PEG procedure volume was associated with lower 7-day mortality after PEG procedure of 4.3%, compared to 7.8% and 6.8% in low and medium volume Trusts respectively ($p=0.045$). Although suggestive of a lower threshold for PEG insertion, the 5 Trusts with the highest rate of PEG insertions in stroke patients had a higher mortality at 30 days (3% compared to 0.9% in the other Trusts).

***Conclusions***

Patient factors are the main determinants of outcome following endoscopy. Analyses of clinical and administrative datasets both require significant man-hours to produce results. Assessing disease severity within HES data is unsatisfactory, limiting case-mix adjustment. However, the data have the advantage of allowing consistent methods of analysis across institutions at a national level providing a more real world analysis than smaller or single centre studies.

# Dedications

I would like to thank my supervisors Dr Keith Bodger and Professor Mike Pearson. Their support, guidance and wise words have been invaluable to me. Not only to enable me to complete my thesis but also to secure my consultant post and move permanently to the fine city of Liverpool.

My thesis would not have been possible without Elizabeth Thompson who instructed me on the intricacies of SPSS and came to the rescue on more than one occasion to stop me throwing the computer out the window. She is now a very good friend.

I must also thank my husband, Richard, for not divorcing me. Your patience has been remarkable!

## Acknowledgments and declarations

My supervisors were Dr Keith Bodger and Professor Mike Pearson.

The original Hospital Episode Statistics data were provided by Northgate solutions. Initial data cleaning was performed by Elizabeth Thompson.

The sedation chapter was conceived and undertaken by me and Dr Sanchoy Sarkar. Jenny McPhilips assisted with data collection. The ERCP, PEG and stroke studies were conceived by me and Keith Bodger. I created the individual datasets for each study. All analysis was performed by me. Statistical support was provided by Keith Bodger and Mike Pearson.

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# 1. Introduction

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**Hypothesis** – Administrative data are a valid resource for measuring quality in healthcare. Hospital Episode Statistics (HES) data can be used to describe variation in healthcare and to assess risk and outcomes.

### Aims and Objectives

The aim of this study is to show that routinely collected hospital administrative data can be used to measure process and outcomes within the National Health Service (NHS). Endoscopy units in the UK are encouraged to audit 30-day mortality but the NHS lacks systems that can capture all procedures and link to subsequent outcome. Death following endoscopy is a rare event. The procedures themselves are generally low risk. However, endoscopy occasionally has to be performed in patients who are at high risk of death or adverse outcome due to their underlying disease. To assess factors affecting mortality following endoscopy requires large numbers of patients to be studied.

I plan to show that hospital administrative data can provide an evidence base for decision making in the healthcare environment. This includes the development and support of clinical indicators and clinical metrics. I aim to demonstrate that this type of data can highlight variation in outcomes. Reasons for variation will be explored and a risk assessment tool will be developed. A number of outcomes will be investigated including mortality and emergency readmission rates.

I will show that Hospital Episode Statistics (HES) can be used in a robust way to support quality improvement within the NHS with specific regard to outcomes in gastroenterology inpatient care. I will describe a large audit of sedation use in

endoscopy as an example of outcomes analysis using clinical data. I will then assess outcomes following endoscopic retrograde cholangio-pancreatography (ERCP) and percutaneous endoscopic gastrostomy (PEG) procedures using HES data. Finally, I will assess the use of PEG procedures in a selected patient population (stroke patients) using HES data.

I will describe the different methods of assessing performance and outcomes in healthcare; the problems, pitfalls and the merits of different strategies.

I will disseminate results to the Gastroenterology community in England as part of the validation process and also to investigate how analysis such as this can be usefully publicised.

This study is part of a larger project (Aintree Health Outcomes Partnership - AHOP) aimed at engaging physicians with hospital administrative data.

Work from the sedation and ERCP chapters has been published as scientific papers in peer reviewed scientific journals.

## Variation in healthcare

Variation in healthcare can be assessed at the level of the individual (doctor or surgeon for example), at institution level, Trust or strategic health authority or larger geographical area. The differences can be in outcomes such as death rates or re-admission rates; in processes such as rates of knee replacements or outpatient visits; or in overall costs.

Where an evidence base for a particular treatment exists, that care should be received by all those with need and should be similar across healthcare providers, with minimal variation. Evidence-based practice has become widely accepted over the last few decades. It is defined as '...the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients' [1].

However, there are many studies showing evidence of geographical variation in healthcare[2-4]. This is evident in healthcare activity for example, rates of surgical procedures and rates of hospitalization as well as in outcomes such as mortality and length of stay. Variation has even been shown between hospitals under the remit of one provider (the American Veterans Affairs Hospitals, whose homogenous patient-base consists of males over 65 on low-incomes) [5].

### Types of variation

Variation can occur with good reason. Variation may be due to differences in the patient population. The local demographic may be sicker, or they may be more likely to use private health care and are therefore not included in the statistics. It may be that Hospital X treats a younger population than Hospital Y. However, these

factors can be adjusted for. Indeed, over large populations these differences may be expected to even out.

Patient preference for one treatment over another can cause variation. This is also acceptable variation and is to be encouraged in a patient-centred approach to healthcare, where patient choice is fundamental. Treatment choices should be based on giving the most effective treatment to an individual, who will benefit from that treatment. The patient should also want that treatment having been provided with appropriate information regarding the risks and benefits to them as an individual.

These types of variation are understandable and can be explained.

It is unwarranted variation that is of concern. Variation is 'unwarranted' when it cannot be explained by patient preference or controlled for i.e. it does not disappear when adjustments are made for the case-mix.

***"Variation in the utilization of health care services that cannot be explained by variation in patient or patient preferences" Right Care NHS Atlas[4]***

For example, why should two areas of broadly similar populations have significant differences in their use of CT scanning? Why should two hospitals have such different mortality rates for COPD patients, despite correcting for age and other patient factors?

***''If all variation was bad, solutions would be easy. The difficulty is in reducing the bad variation which reflects the limits of professional knowledge and failures in its application, while preserving the good variation that makes care patient-centred.'' Professor Al Mulley BMJ 2010***

The Dartmouth Atlas, founded by John Wennberg, showed that high spending healthcare providers achieved outcomes that were no better and, in some cases, were worse than lower spending providers. This variation could not be explained by patient factors. In fact the increased availability and therefore increased utilization of services was a key factor in increased costs. The increased mortality was thought to relate to more time spent in hospital. By being in hospital more often the patient was exposed to increased errors, hospital acquired infection, procedure complications and unnecessary investigations. It was not because the patients were any sicker. These studies confirmed that having more doctors per capita was associated with more consultations and more tests; having more beds was associated with more hospitalisations[2;3;5].

***''It is the frequency of use of supply-sensitive services by chronically ill patients that distinguishes high cost regions from low cost ones.... Not improved care, not better 30-day mortality rates, and not higher procedure rates...'' John Wennberg founder of the Dartmouth Health Policy Institute[3]***

## Why should variation be measured?

Lord Darzi outlined plans to improve measures of care quality in his 2007 report; 'High Quality Care For All – NHS Next Stage Review Final Report'[6]. This included outcomes that would be available to patients enabling them to make informed choices regarding their care. The report highlighted concerns over 'unacceptable and unexplained variations in the clinical quality of care in every NHS region'. Lord Darzi acknowledged improvements brought about by the introduction of nationally accepted standards (National Service Frameworks). The report emphasised the need for good information. Information that would show clinical teams where

improvement is needed and allow clinicians to assess the effect of any changes they implemented.

***'Awareness is the first important step in identifying and addressing unwarranted variation; if the existence of variation is unknown, the debate about whether it is unwarranted cannot take place.' Right Care NHS Atlas*** [4]

Identifying unwarranted variation should not be punitive. The process should ask why there is a difference and identify better care processes which can be adopted by others. With improved systems the over-use of low value interventions can be avoided and the use of high value interventions encouraged. By targeting unwarranted variation, healthcare can be made more efficient, more effective, higher quality and better value. These improvements can be seen in time, finances and in patient outcomes and ensure that evidence based care is received by all those with need.

## Methods of identifying variation

Identifying variation requires the setting of an acceptable result, or range of results for a process or outcome. This might be a nationally set standard. It may be the national average. The standard may simply be your consultant colleagues or neighbouring hospital. This process of 'benchmarking' is widely used in industry to encourage performance improvement and the sharing of good practices. It is increasingly used within healthcare with the use of clinical indicators and clinical metrics.

***''A clinical indicator is a tool that can help identify possible problems and/or opportunities for improvement within a service or treatment. Used appropriately indicators can be used to compare variations in how the same services are provided in different areas or against national benchmarks.***

***Indicators can be used as a basis for reflection on current practice and act as the starting point for improvements in the quality of patient care.''***

***NHS Scotland (www.clinicalgovernance.scot.nhs.uk)***

How do we compare one hospital's results with another? They are unlikely to be exactly the same. A statistically significant difference in results may not represent clinically significant differences in performance. Ranking results from different providers may give the impression that those ranked at the lower end are performing poorly, when it may be that all are performing at acceptable levels with a range of good to better performance. The difference between the top and bottom may not be statistically or clinically significant. Where a threshold of performance is set, it is easier for a provider to know if they are performing at acceptable levels but will not necessarily encourage quality improvement beyond that. This method does not promote the sharing of ideas between institutions.

It is important to understand that statistically significant variation from an accepted normal result may not always be clinically important. It may represent the phenomenon of 'over-dispersion'[7]. This may indicate that the indicator is not appropriate or that the necessary case-mix adjustment has not occurred. It may be that a range of results would be more appropriate rather than a single target result. It may be necessary to sub-classify institutions to make results comparable; for example, analysing tertiary hospitals and district general hospitals in separate groups.

Results may change over time. As poor outcomes tend to be rare, assessing outcomes over too short a period of time may miss the event entirely. Alternatively, a poor outcome for a provider in one year does not necessarily reflect poor performance. However, poor outcomes over several years would suggest there is something amiss.

Comparing one provider with another or a small number of providers within a small geographic area may not be adequate to identify important variation. It may be that the populations are too small, or too different to make sensible comparisons. It may be falsely reassuring. The methodology for measuring results may be very different making any comparisons invalid. A wider assessment looking at many providers, with a uniform approach to data collection will provide more robust results.

The use of routinely collected data is increasingly recognised as a mechanism for measuring performance. It allows data to be collected from a large number of providers across geographical areas that are consistent in format and continually updated. It has formed the basis of many outcome studies in the literature and is used by private organisations such as Dr Foster and CHKS, to provide benchmarking data to the NHS.

Recognising variation, analysing reasons for variation and efforts to eliminate variation are continuing processes in manufacturing systems to ensure quality improvement and efficiency. In 1924, Walter Shewart proposed the use of statistical control charts to distinguish between warranted (or acceptable) variation and un-warranted variation (also known as chance-cause and assignable-cause variation; or common-cause and special-cause). By identifying and eliminating special cause

variation, quality could be improved. This strategy has been employed by many industry companies over the years[8]. Statistical process control is one method of identifying variation in the healthcare setting and has been utilised in several studies.

Statistical process control analysis can more easily be applied to large, national datasets as it incorporates defined outcomes such as mortality but measures the variation in this outcome over time and compared to a standard e.g. national mean, guideline. Each event has an a priori risk of occurrence for an individual so that if the event occurs in a low risk individual the 'penalty' is higher than if the event, for example death, occurs in an individual with pre-existing high risk e.g. due to older age and the presence of co-morbid disease. [7;9-18]

## Case-mix adjustment

For any comparisons to be just we must ensure we are comparing like with like as far as possible. Each patient arrives at hospital with their own unique set of factors that will affect the ultimate outcome of their admission (all patients are not created equal). Without correcting, or controlling for these factors it is impossible to assess the quality of hospital care received by a patient. These factors may interact and thus adjusting for them is complex.

Case-mix involves the primary diagnosis and its severity; socio-demographic factors such as age, gender and socio-economic status; functional status and co-morbidity.[19] It is generally accepted that healthcare outcomes such as mortality cannot be compared across institutions without some form of risk-adjustment to account for these differences in case-mix. Many methods of risk-adjustment have

been developed but it is known that results for a hospital can differ depending on which method is used. This will obviously have significant impact on comparisons with other institutions[20].

How these factors are defined and their effect in a given population can vary, in which case they may add in bias. For example, the calculation of standardised mortality ratios (SMRs) can be effected by variation in definitions such that a healthcare institution may be given a falsely high SMR. This has been termed 'the constant risk fallacy' or 'risk adjustment fallacy' [21]. It occurs where the presumption that a risk is constant across different institutions or different groups of patients is false [18;21-27]. To explain this further, for a variety of possibly unknown reasons, Hospital A may have a lower threshold for admitting a patient with condition X, than Hospital B. This may be because Hospital A is in an area where social support is less available or because they do not have a pathway of care that encourages discharge of this particular patient (e.g. ambulatory care pathways).It may be that Hospital A simply has more beds available. Thus, although the theoretically identical patients are equally unwell, other factors mean that Hospital A will admit this patient whereas Hospital B will not admit the patient. Thus, Hospital A's mortality rate will be diluted by admitting less sick patients than Hospital B.

Factors external to the hospital may influence results. For example, more deprived areas can have a lower census completion rate which means the denominator population is falsely reduced in such areas.

Currently the perfect risk-adjustor does not exist but to forego adjustment completely would make analyses meaningless.

## Outcomes analysis in healthcare

### Which outcomes?

There has long been a desire within Healthcare and Government to develop information strategies that provide routine, efficient capture of performance information within the NHS. There are many aspects of healthcare that can be measured but deciding which should be used to assess performance is a complex decision. Quality and performance are made up of many individual functions of healthcare. Measuring all of these would be inefficient, so which do we choose? We need factors that are relatively easy to measure and that provide pointers to reasons for poor performance so they can be rectified. The outcome measures need to provide timely results so that harm is minimised. The factors need to provide clinically relevant results that allow clinically significant improvements in healthcare to be developed.

The purpose of healthcare is to maximise quality life years for an individual through the accurate detection, diagnosis and therapy of disease or injury. Factors such as life expectancy and disease incidence or prevalence can be used as measures of performance in healthcare. However, these factors are not specific enough to allow a provider to identify reasons for poor results and be able to target specific areas of care to improve performance. For example, life expectancy: If we are living longer, healthcare must be better? Life expectancy is affected by more than just healthcare. Education, social care, environment will all impact on life expectancy. It is not a specific enough measure even if used within certain disease states e.g. breast cancer. Life expectancy can though, be used as a valuable measure for longer

term analysis of healthcare quality and is used as a means of comparing overall care and quality of life across wider geographical areas e.g. one country with another.

Volume of activity undertaken by a provider can be used to highlight variation between providers. Rates of elective surgical procedures can be compared to national averages. Outcome measures can assess the success of treatment with factors such as complication rates, readmission rates and mortality. These groups are relatively easy to measure and are necessary for identifying unwarranted variation. However, they will require additional analysis, perhaps at a local level to identify what needs to be done to improve performance.

Measures that directly assess the *process* of care are more useful as they can provide a clear direction for improving practice. However, it can be the most difficult group of factors to measure. Factors in this group may include measuring adherence to evidence–based guidelines[21]. For example, the proportion of stroke patients cared for on a stroke unit, or the proportion of patients with a myocardial infarction discharged on a beta-blocker.

Healthcare providers have a duty to monitor performance and maintain standards. Performance in the NHS encompasses many factors including; productivity, efficiency, cost-effectiveness, safety, improved survival, patient satisfaction, quality, innovation and research. In 1997 the NHS executive published a framework for assessing performance and quality[28] that moved beyond simple 'bean counting' of procedures. Quality care would be defined by six domains that could be assessed: Health improvement; fair access; effective delivery of appropriate care; efficiency; patient/carer experience and health outcomes of NHS care. It also described criteria

for assessing possible indicators stating that they should be: attributable; important; avoid perverse incentives; robust; responsive and possess usability and timeliness. In describing proposed performance indicators the report did acknowledge that performance can be affected by factors that are outside the control of NHS hospitals and that caution needed to be exercised in comparing results across institutions.

Sheila Leatherman (Professor in health care systems and performance) wrote an editorial in the BMJ just after 'The NHS Plan' had been published in 2000[29]. In it she described the unique setting of the NHS as a truly national system of care, where decisions for improving care, such as reducing waiting times, would cover the whole nation. She highlighted the core values of *'equity, efficiency and effectiveness*' and the importance of learning '*from its own best practices and innovations and spread those good ideas throughout the nation'*. The NHS plan called for increased measurement and accountability, underlying the importance of good data and good data analysis.

***'....we can only be sure to improve what we can actually measure.' Performance Metrics – We Can Only Manage What We Measure Well (www.PMcrunch.com)***

In Leatherman and Sutherland's review of the NHS plan for the Nuffield Trust in 2003[30] their main recommendations included the formation of a quality information centre, engagement of public and patients and, finally, engagement of clinicians. They believed that change and improvement would not happen or be sustained without clinicians themselves being able to take ownership of the quality initiative.

Simply setting targets against which institutions can monitor their own performance will not always bring about quality improvement. Setting targets can affect behaviour which undermines the aim of improving performance. If the wrong outcome is being measured this can even be detrimental to overall performance with other aspects of care being neglected for the sake of hitting a target. For a (crude) example increasing rates of hip replacement may simply mean more inappropriate operations on frail patients rather than improving outcomes from hip fractures.

What is 'Quality'? In his 2008 review[6] of the NHS, Lord Darzi stated quality should include the following measures: Patient safety, patient experience (quality of *caring*) and effectiveness of care. Measures would include clinical domains such as survival rates and mortality but also measures of patient perspective of effectiveness including the use of 'PROMs' – Patient reported outcome measures.

The report described the concepts of 'metrics' and 'quality indicators'. These consist of a national framework of comparable measures against which hospital departments can measure their performance. Measures include factors such as length of stay, operation time and 'time to be seen' and can be expanded to include measures developed locally to incorporate local circumstances. The report has a strong emphasis on transparency within the NHS; the importance of measuring performance and being accountable for the results is integral to the notion of quality improvement. Publishing details on performance is thus a key feature of improvement (and subsequently part of the NHS constitution[31]). The process enables patients to make informed choices; institutions to compare and improve

their performance and commissioners (and providers) of healthcare to be able to prioritise and plan appropriately (CQC, The Information centre, and NHS Choices website).

The Darzi report discussed the role of incentives for quality improvement with a payment system that recognises clinical complexity and rewards innovation. This again underlines the importance of good accurate data in healthcare.

Which indicators are good at identifying quality healthcare and which can be used to monitor improvement is not fully understood. Engagement with their use has been variable perhaps due to concerns of 'gaming' and not wishing to publicise results for fear of them being worse than your 'competitors'. Developing clinical indicators to monitor performance has been a challenge not just in the UK but also in the US and Australia. In particular, improving the effectiveness of healthcare requires complete and accurate clinical information that is easily accessible to those who work within it[32].

## Data sources for outcomes analysis

There are huge amounts of data produced by, and contained within, the NHS. Unfortunately, this data are often not used, not known about, used inappropriately or inconsistently. The need for transparency and a more rigorous and robust approach to data use in the NHS was highlighted in reports on the Bristol paediatric surgery inquiry[33;34]. In the following section I describe the various sources of data used within the NHS and outline their advantages and disadvantages. I will describe how HES data are already being used and suggest how its use can be improved.

**Audit -** All hospitals carry out local audit and will compare their results with previous years, other groups within the same hospital, other local hospitals and further afield, in addition to comparisons against national or international standards of practice. This local level audit can be clinically very rich and address issues specific to a particular hospital or geographic area. However, they are often modified every time they are done, or may not be done regularly. Methods of data collection vary between institutions making comparisons invalid. Often, audit is performed at too small a scale to be truly useful with case numbers of fewer than 50 not uncommon. This reduces the power of such audits to bring about changes in practice. Audits can also be incredibly time consuming, requiring many man hours to complete data collection. There will continue to be a place for such work. However, larger scale analysis allows more statistically robust assessments of outcomes and analysis nationally is essential to improve healthcare for all.

Larger scale audit can provide very useful data that can impact significantly on patient care. For example the Myocardial Ischaemia National Audit Project (MINAP) set up in 1998. This is based on standards set by the National Service Framework and allows individual units to track their performance against these targets over time. The project continues to collect data from all hospital in England and Wales and has shown significant improvements in performance. As with other data sources within the NHS, large audits are able to look very specifically at a particular diagnosis or group of diagnoses and require additional data collection to that which is routinely collected by hospitals.

**Morbidity and mortality reviews including National Confidential Enquiries (NCEPOD) –** Case by case review of unexpected outcomes or complex cases can highlight error or deficiencies in local care pathways and be a stimulus for improvement. They are of educational value in describing unusual cases or atypical presentations. They can help individuals to improve technique and practice. Where known, comparisons with accepted mortality rates for a given condition can be made but robust case-mix adjustment may be lacking to make comparisons meaningful. On a national level the National Confidential Enquiry into Patient Outcome and Death has published over 30 reports since it began in 1987 (as the National Confidential Enquiry into Peri-operative deaths). The reports look at the care of patients who have died following a particular operation, procedure or event. Cases are identified by local reporters and from HES data. Questionnaires are sent to the consultants involved in the care of the patient and extracts of case notes are requested. This information is anonymised and then reviewed by an expert panel. Deficiencies in care are identified, described and conclusions drawn as to where improvements in care could be made to reduce mortality. The NCEPOD method essentially follows the principles of the mortality and morbidity (M&M) meeting described above and therefore shares the M&M's advantages and limitations. Additional limitations of the NCEPOD reports are the poor data capture and focus on deaths alone. For example, of 1756 deaths included in the report into surgery on elderly patients, only 600 full datasets were obtained and the questionnaires were completed by fewer than 65% of the surgeons and anaesthetists identified[35].

**Registries and Clinical datasets** – There are an increasing number of registries being established within healthcare systems around the world. These cover a number of diseases and healthcare interventions, from joint replacement registries, inflammatory bowel disease and the more familiar cancer registries. There are eleven cancer registries in the UK. Standard datasets are submitted to the Office for National Statistics for national cancer incidence data. Data are acquired from many sources including HES, cancer centres and MDTs and death certificates[36]. These datasets provide incidence and prevalence data and can facilitate audit within a field. The data are not all routinely collected and therefore requires additional staffing and hours. Whether local, national or international, such datasets have the advantage of clinical depth over administrative datasets. However, constructing and maintaining clinical datasets requires money and man-power. If contribution to such datasets is not mandated capture of cases will not be 100% and there may be bias in which cases are included.

**Clinical trials** – Randomised controlled trials will assess baseline characteristics and the impact of novel therapy on outcomes within a highly regulated population. Trials will provide evidence for best practice. They can be independent or funded by the pharmaceutical industry. Epidemiological studies may provide more 'real-world' results than controlled trials, but also focus on particular disease processes or patient groups. Trials require time and financial input and are not designed for continual assessment of outcome factors over a long period for an entire population.

**Patient surveys** - Surveys are conducted by healthcare organisations, governments and non-governmental organisations around the world. The problem with any survey is that it is completed by a self-selecting population unless fully mandated. Returns are rarely 100% and the number of individuals questioned may be insufficient to provide meaningful results. The style of questioning may lead to bias. Collecting and collating the data is time and labour intensive.

**Administrative databases** - provide huge amounts of data but are seen as containing very limited clinical information. Historically there have been doubts about the accuracy and depth of information entered into the databases but with the advent of payment by results and increased public awareness of hospital outcome data and patient choice there has been a huge expansion in the number of publications using this data. The advantages of administrative datasets include their size and population coverage. They contain historic data going back many years allowing analysis of trends. In addition, the data are less prone to bias and phenomena such as the Hawthorne effect.[37]

The ideal dataset is a nationally integrated system of fully electronic patient records with automated regular analysis that can provide useful information both at a local and national level on performance and practice that can be disseminated widely in a timely fashion. The data that are generated will be clinically relevant, non-judgemental, and useful. Data will be stored indefinitely so that performance can be assessed over many years (often a more useful analysis). The electronic records will include clinical data such as blood results, radiology reports, medication and

physiological data such as blood pressure and weight, as well as demographic and sociological data.

Patients will have access to clear data which will help them make choices but perhaps more frequently reassure them that care within the NHS is of a high standard and that the organisation as a whole is open, transparent and continually striving for improvement. The data will be used by clinicians, managers, the public, policy makers and regulatory bodies. It will allow benchmarking of performance over time and between healthcare providers. Clinicians would have ownership of the data. The process will highlight significant deviations from accepted 'norms' that allows hospitals to quickly investigate further to enable them to advertise better practice and isolate poor practices and instigate change. The database could be used for robust research including epidemiological analysis of particular diseases or patient groups, and perhaps even clinical trials.

Although many hospitals do have electronic patient records we are a long way off the nationally integrated database described above. For reasons of cost, time, technology, patient confidentiality, 'big brother' concerns and other factors a complete 'fit for purpose' database has not yet been realised.

What we do have is Hospital Episode Statistics. HES were devised as an administrative database to aid resource allocation and service planning in the National Health Service. From 2007 HES data have been used to calculate hospital income via development of 'healthcare resource groups' (HRGs), tariffs and 'payment by results' (PbR). The potential for outcomes research based on HES data

has long been recognised with many papers looking at surgical procedure volume and outcome (usually mortality).

Hospital Episode Statistics contain data about *every* episode of hospital inpatient care within the NHS in England. It is not speciality specific – the same data are collected for everyone. Analysis of data from many institutions can be performed in a consistent way, making comparisons more valid. Using HES for outcomes research is cost-effective and allows large numbers of admissions and patients to be studied over a long period of time (essentially an entire population). It cannot be used to identify poor quality care for an individual but is a means to assess patterns of care over time and highlight variation in outcomes that can then be studied more closely by other means. It can direct further, more expensive research.

However, the datasets are huge and potentially unwieldy. Extracting data requires computer power and time. The data has been used by Government departments and private, external benchmarking companies such as Dr Foster[38] and CHKS[39], to provide outcomes analysis for providers and the public but this data interpretation must be viewed with caution and in context.

In the next section I will describe how Hospital Episode Statistics are derived, with a detailed look at the coding process. I will discuss how HES data has been published and how I think HES based analysis can be improved.

## ICD, OPCS classification systems

### ICD coding

The International Classification of Diseases (ICD) system has existed under the auspices of the World Health Organization (WHO) since 1948. The need for an internationally agreed, consistent method of coding causes of death was first recognised in the 1850s. In 1893 the 'International List of Causes of Death' was introduced by the British epidemiologist William Farr (1807 – 1883). He is said to be one of the founders of medical statistics and urged the adoption of a uniform classification system[40]:

> ***"The advantages of a uniform statistical nomenclature, however imperfect, are so obvious, that it is surprising no attention has been paid to its enforcement in Bills of Mortality. Each disease has, in many instances, been denoted by three or four terms, and each term has been applied to as many diseases: vague, inconvenient names have been employed, or complications have been registered instead of primary diseases. The nomenclature is of as much importance in this department of enquiry as weights and measures in the physical sciences, and should be settled without delay."***[41]

Over the decades the coding system has been developed and expanded. Early on, Farr recognised the need for a system of classification for non-fatal disease and this was endorsed by Florence Nightingale in her paper, '*Proposals for a uniform plan of hospital statistics*' in 1860. Initially, however, non-fatal disease was classified in a separate, parallel list. Only from its sixth revision in 1948 has the ICD included codes for causes of morbidity as well as causes of death.

The codes fit into broad categories, some based on disease type, others disease site and there are codes pertaining to symptoms and signs rather than specific diseases.

Modifier codes have been introduced to provide information on social factors, types of interaction with healthcare and mode of injury. Codes describing side effects and complications of treatments have been added more recently. The codes are created with 3 to 5 digits which progressively add detail to a clinical diagnosis[42]. The primary diagnosis is usually described by the first code attached to an episode of care. If a diagnosis is not apparent then the first code will describe the main symptom or sign. Additional codes can be added to describe secondary diagnoses. The total number of diagnostic codes that can be attached to an episode of care has risen from 7 before 2002 to a total of 20 since 2007. Between 2003 and 2007, 14 codes could be used. Most episodes of care will have fewer than the maximum number of codes attached to it.[43]

ICD-10 was endorsed by World Health Organisation in 1990 and first used by its member states in 1994[44]. Some countries have added their own specific modifications. All member states are required to use the most up to date revision for collection of their mortality and morbidity statistics.

There are weaknesses within the ICD coding system[42]. There are no values attached to codes. If someone is in respiratory failure and that is entered in the notes then the coders will apply the code J960 (acute respiratory failure), J961 (Chronic respiratory failure) or J969 (Respiratory failure, unspecified). There are no set criteria such as a range of oxygen or carbon dioxide saturation values to indicate when a particular code may be used. Similarly for anaemia, there are no set criteria for haemoglobin values at which the term can be applied. Whatever diagnosis is written in the notes will be coded. The above examples illustrate another area of

concern – the 'unspecified' codes. There are many of these codes which are clearly open to being used as a default code when limited information is present and may very much misrepresent the patients' true clinical history. Diagnostic codes can overlap such that more than one could be used to describe the same illness. What is coded as bronchitis in one place (codes: J40X, J411, J418, J42X) may be coded as chronic obstructive pulmonary disease (J440, J441, J448, J449), or emphysema (J431, J432, J438, J439) elsewhere.

More codes have been introduced that describe iatrogenic events, complications or side effects of treatment. Even with these explicit codes available their use is variable and the lack of dates associated with diagnostic codes may still make them difficult to interpret. It is difficult to paint a picture of a patient's disease status with ICD codes alone. The chronology of disorders may not be apparent. Although there are some codes that do specifically state whether the condition is acute or chronic the order of occurrence in a patient's admission will not be ascertainable. How severe a condition is and how the different diseases are interacting is a complex concept that ICD codes alone cannot illustrate. However, by viewing all codes attached to an episode of care, using the other information available within the database and by linking across an individual's hospital admissions it is possible to make inferences about what has occurred. Robust conclusions about complications can be made[45]. It must be remembered that the OPCS codes for surgical procedures do have dates and therefore can be helpful in describing a patient's journey.

In 1983 in the US and in 2007 in the UK the current hospital reimbursement systems were introduced i.e. Medicare's prospective payment system in the United States

and ‘Payment by results’ in the United Kingdom. These introduced vastly new roles for the ICD coding system: roles that the ICD was not necessarily designed for. What codes are used, how many are used and in what order (primary or secondary diagnosis) may impact significantly on how much a hospital gets paid for a specific admission or indeed how much a patient or insurer gets charged. There has been evidence in the past that this has led to manipulation of coding at discharge.[42]

## OPCS Coding

OPCS (Office of Population, Censuses and Surveys Classification of Surgical Operations and Procedures - 4th revision) codes are 4-digit codes that are used to describe clinical procedures and interventions performed on patients. The first digit is a letter that denotes which body part or system is involved. The 4th digit provides an additional level of precision where required. They may be used singularly to describe a procedure such as a skin biopsy or they may be used in combination to describe a whole ‘operation’. Up to 12 codes can be attached to an episode within HES. There are more than 6,000 OPCS codes used at the 3- or 4-digit level.

A classification of surgical operations was first introduced in the UK in 1944. The 4th revision of the OPCS system was implemented in the NHS in 1990. The system is reviewed annually to keep up with changes in current medical and surgical practice. Recent revisions have also taken place to support changes to the hospital reimbursement process: Payment by results (PbR) and the use of health resource groups (HRGs)[46].

OPCS codes are explicit with clear interpretation of what they represent. They have been seen, therefore, as more robust than ICD codes. Classifying surgical processes

is always going to be far more straightforward than classifying medical conditions where individual variation in disease manifestation is so great. There are many, many published papers using OPCS coding analysis to analyse surgical procedure volume and mortality.

## Hospital Episode Statistics (HES)

### Background

The HES database was devised in 1987 with data entry beginning in 1989. Prior to HES, data was collected on just 10% of hospital inpatients. More than 12 million new patient episodes are now added each year covering all patients admitted (as inpatients or day-cases) to English NHS hospitals. More recently, data from outpatient and emergency department attendances have also been collected. The rest of the UK have their own, similar systems all based on the international coding strategies for diagnoses and procedures (OPCS and ICD coding). Data collected in HES includes clinical information on diagnoses and operations, administrative information such as admission and discharge dates, standard demographic data as well as postal codes and deprivation indices. Unique patient identifier codes were introduced in 1997 and in 1998 consultant GMC codes were added to the original aggregate dataset to allow individual consultant activity to be assessed (in theory).

Many of the data items in HES are included in the national Commissioning Data Set (CDS) and are generated by the patient administration systems (PAS) within each hospital[43]. Clinical information is entered into the PAS by clinical coders using the ICD and OPCS coding systems (see below). Other information such as consultant allocation, type of admission, admission date and discharge date are added by hospital administrative staff e.g. ward clerks, ward staff, clinic receptionists. Extracts from PAS are submitted to the secondary uses service, a central secure data warehouse for the whole NHS. The data are processed and cleaned before being sent to HES and other users including public health, parliamentary questions and

NHS websites. Further data cleaning and derivation of additional fields occurs to complete the HES dataset[43].

## Structure of HES data

The period of inpatient care from the date of admission to discharge is termed an inpatient 'Spell'. This may consist of periods of care under more than one individual consultant. These periods, attributable to a single consultant, are termed Finished Consultant Episodes (FCEs). These FCE are the basic unit of HES. Most spells will consist of only one FCE. The date of discharge defines the episode and indicates the year it occurred. If an episode runs across the end of one financial year into the next year the episode will be ascribed to the latter year, not the year of admission. This makes sense if it is remembered that complete information from an episode of care can only be entered into the patient administration system and then HES once the patient has been discharged.

## What is clinical coding?

***''...the translation of medical terminology, as written by the clinician, to describe a patient's complaint, problem, diagnosis, treatment or reason for seeking medical attention, into a coded format which is nationally and internationally recognised.'' - NHS Connecting for Health, Clinical Coding Instruction Manual.***

When a patient is discharged from hospital their case notes are accessed by clinical coders. Coders are specially trained, non-clinical, administrative staff. They review all the documentation relating to a patient's admission including written notes, radiology and pathology results and procedure notes. Where present they will review the discharge summary. In some cases ICD and OPCS codes may have already been assigned by the medical or surgical teams. If not, the coder will read

through the notes applying codes to diagnoses and procedures documented. These codes are entered into the hospital patient administration system. How codes are applied must follow set methods. Certain codes are superseded by others to prevent long lists of similar codes being applied and included in the data. There are a number of rules that have to be adhered to by the clinical coders – they are not allowed to make assumptions about diagnoses. For example, if a question mark is placed next to a diagnosis that diagnosis cannot be coded. They can only code fact. [47]

## Limitations of HES data

The use of HES data to perform risk-adjustment when analysing hospital outcome data has caused concern due to the perceived variation in how codes are applied within the HES dataset. The same general condition can often be coded using several different codes. In theory, the code in the first ICD position is the primary diagnosis but often this position is occupied by a symptom code. The relevance of codes in lower order positions is not easily or reliably interpreted. Knowing whether to look for your condition of interest in just the first one, two, three or perhaps all positions may significantly influence the results you obtain.

Small variations in how institutions code their admissions can lead to significant differences in measured performance when compared to other institutions. Case-mix adjustment is limited without the means to acknowledge disease severity or other confounding factors such as smoking status.

## Improving the validity and value of HES data

Several strategies will be employed in this study to make the analysis of HES data more robust. Running code frequencies for each position will illustrate where the majority of target codes are found and thus only cases with codes in those positions will be included in analysis. Cases with target codes in later positions will be presumed to have the condition as a co-morbid disease rather than as the primary reason for that admission and will be excluded.

The data validity can be improved by several means. Coding errors on an individual patient level will be difficult to identify. However, results at Trust level will be assessed and cases from Trusts with 'poor data' will be excluded from final analysis. Poor data will be identified on face validity, comparison with results for other Trusts and comparison with results from other data sources e.g. local and national audit. Thus, data from Trusts with extreme results will be excluded. For example, Trusts with very low volumes of ERCP procedures or, Trusts with zero mortality despite very high case numbers.

The value of HES data can be developed and enriched beyond simple volume analysis by linkage of data. Internal linkage allows tracking of individual patients over time and across institutions. Their journey through healthcare can be assessed and compared. Linkage is performed using the unique identifier code assigned to individual patients within HES. Once the target population has been identified those unique codes can be used to search backwards and forwards to identify further admissions for those particular patients. Chosen events can be 'flagged' by creating additional variables that are attached to the patient code. Ultimately, data over a

specified time period can be collected for the target patients into a separate database for further analysis.

HES data can be linked to external sources of data such as death status and date of death from the office of national statistics (HES data contains a variable for inpatient deaths only). This will provide much more robust mortality analysis. Data from cancer registries, networks and audit can also be linked using the patient identifiable data stored within the HES dataset. Where patient data cannot be directly linked the validity of HES data can be verified by comparing simple counts of patients or procedures with local level data or published research from other sources. This is particularly useful with Trust level data which can be checked against local audit or procedure reporting systems.

## Publication of HES data analysis

Publication of HES data is aimed primarily at healthcare providers and commissioners[30]. The data are used to aid budget setting, financial reimbursement, service planning and prioritising.

It is also used to monitor trends in healthcare, to aid outcomes research and epidemiological studies. HES data allows comparisons to be made between institutions and facilitates performance monitoring.

Performance ratings for acute NHS Trusts were first published by the Government in 2001. This was followed by publication of performance indicators in 2002[48]. The Commission for Health Improvement (CHI) was the independent regulator set up to monitor NHS performance at that time. This body has been superseded by the Care Quality Commission.

As the NHS is ultimately accountable to the general public for its performance, there has been a drive to put data within the public domain for public consumption. This, in theory, will empower patients and allow them to make more informed choices about how and where their healthcare occurs. However, unregulated publication of hospital data into the public domain, without clinical context or analysis of longer term trends, may be detrimental to patient Trust in the healthcare establishment. It may be misinterpreted not only by the public but also by other healthcare providers and commissioners.

Although under the remit of the Department of Health, much of the actual analysis has been performed by private companies. Specifically; Dr Foster[38] has provided

much of the outcomes analysis for patient consumption; CHKS[39] provide data analysis for the Government and specific providers in primary and secondary care. The King's Fund[49] and The Nuffield Trust[50] are both independent, charitable Trusts that aim to improve healthcare policy in England and the rest of the UK. Their publications are also aimed at professionals and policy makers rather than healthcare consumers or patients.

***"The main contribution of the Dr Foster group has been to bring a level of communication skills to performance reporting that government agencies have failed to achieve." Professor Martin Marshall in 'The quest for quality in the NHS'[30]***

### *Why publish HES data?*

Publishing data gives transparency to healthcare practices and allows planning of services. However, it is the potential to stimulate change and improve performance that is perhaps its most powerful attribute. For this to occur there must be confidence in the data. This requires engagement of clinicians with the production, analysis and use of healthcare data so that change can be implemented, monitored and managed in the best way.

My thesis aims to show that HES data analysis can be improved. Firstly by having clinicians leading the data analysis and secondly, by engaging clinicians in general with the process of analysis. This will mean that results obtained provide useful information that can lead to improvements in clinical healthcare.

# 2. Sedation

# 2. Sedation


## Abstract

***Background and aims:*** Gastrointestinal endoscopy plays a significant role in both diagnosis and treatment of gastrointestinal disorders. Guidelines have suggested that poor outcomes after endoscopy are associated with higher sedation doses. However, adverse events following endoscopy are rare, making it difficult to gather robust data to identify important factors affecting outcome. Detailed information on sedation use is not contained within hospital administrative datasets (HES) and therefore this study was based on a clinical dataset.

This chapter describes how a large clinical database was used to assess outcomes following endoscopic procedures. Specifically, it describes a single centre audit of endoscopy outcomes before and after interventions to improve sedation practice.

***Methods:*** Cases were identified retrospectively from the endoscopy unit's electronic database. All endoscopic procedures (except ERCP) performed within a 6 month period were identified and the endoscopy reports assessed.

Following this audit, changes in local sedation practice were implemented. These changes included the creation of a unit sedation policy and the introduction of pre-packed sedation syringes.

Fifteen months after the implementation of the new sedation policy the audit was repeated. Again this was a retrospective analysis of 6 months of endoscopy including all endoscopic procedures except ERCP. Findings from the two audits were compared to assess if the changes in practice had brought about improvements in outcomes.

***Results:*** In 2004 a total 7,234 procedures were identified in 5,999 patients. In 2006 the total number of procedures was 7,071 in 5,946 patients.

Mean sedation doses fell from the first to the second year for all types of endoscopic procedure and for both midazolam and fentanyl (Midazolam: 4.9mg to 2.9mg $p<0.0001$; Fentanyl: 77mcg to 66.7mcg $p<0.001$.). In 2004 19% of unit endoscopists were using a mean dose of greater than 5mg midazolam. In 2006 none of the endoscopists had a mean dose of greater than 5mg (p=0.005).

The rate of overall adverse events (death, immediate complications, use of reversal agent) did not change from the first to the second audit. The overall 30-day mortality rate was 0.7% in 2004 and 0.8% in 2006 ($p=0.5$). However, the rate of unsuccessful procedures due to patient intolerance did increase from 0.1% to 1.9% ($p<0.0001$).

***Conclusions:*** Despite achieving significant improvements in sedation practice, these improvements did not translate into improved outcomes in terms of mortality, complications or patient satisfaction. Indeed lower sedation doses may have had a deleterious effect on outcome.

The use of a clinical database gave clinical depth to the study with detailed analysis of sedation doses and causes of death. However, even with improvements made to the electronic endoscopy database it was still time consuming and required significant investment in time and manpower.

It is hypothesised that using an administrative dataset such as HES to assess outcomes, including mortality, following endoscopy would be preferable to

analysing a clinical dataset as was done here. Administrative datasets would allow consistent, reproducible analysis of large numbers of cases over time.

## Introduction

This chapter centres around one method of analyzing performance in healthcare: audit. The process of recognizing a standard of practice and measuring one's own practice against that standard is widely used in the National Health Service. Here I shall review the literature on measuring outcomes in endoscopy and describe a large, single centre audit. The advantages and disadvantages of this type of audit will be discussed.

### *Background*

Endoscopy plays a significant role in both diagnosis and treatment of gastrointestinal disorders. Gastrointestinal endoscopy is performed in over a million people each year in the UK[51]. This includes at least 136,000 therapeutic procedures including percutaneous endoscopic gastrostomy insertion (PEG), endoscopic retrograde cholangiopancreatography (ERCP), endoscopic stenting and polypectomy[52]. Currently 0.95% of the population are referred for upper gastrointestinal endoscopy by their general practitioners[53].

Although on the whole outcomes are good there is a morbidity and mortality attached to these procedures. Upper gastrointestinal endoscopy has been reported to have a morbidity of 1 in 200 and a mortality of 1 in 2000 [54]. Morbidity and mortality rates after colonoscopy have been reported at lower than 1 in 500[55]. There are a number of papers looking at outcomes following gastrointestinal endoscopy, but figures for complications and deaths following these procedures vary widely. Studies have reported morbidity rates from 0.2% to 10% and mortality rates of zero to 20% in emergency endoscopy for variceal bleeds to over 70% in

certain groups of patients having PEG (percutaneous endoscopic gastrostomy) insertion. This variation may relate to the small size of the study populations, often fewer than 2000 cases, the case mix and definition of a complication.

The most commonly reported adverse events in endoscopy are cardiorespiratory. Cardiorespiratory events are also the most common cause of death following gastrointestinal endoscopy. The observed death rate in the four weeks after upper gastrointestinal endoscopy for pneumonia, myocardial infarction and cerebrovascular accident is 1.7 times the expected rate for the general population.[54-60]

Several groups have proposed an association between higher doses of sedation and higher rates of morbidity and mortality[54;61] Risks relating to the use of sedation include the use of reversal agents, respiratory depression, hypoxia, cardiac ischaemia and infarction, hypo- and hypertension, aspiration pneumonia and arrhythmias. Evidence from small observational and controlled studies has confirmed that significant hypoxia, tachycardia and arrhythmias can occur during upper and lower endoscopy and this is seen in sedated and unsedated patients. Some of these controlled studies have shown no significant differences between the two groups[62]. In other controlled studies the incidence of hypoxia and desaturation was significantly increased in sedated patients but this effect was abolished by the administration of supplementary nasal oxygen in sedated patients[63-65].

Cardiac ischaemia has been shown to occur in patients, with known coronary heart disease, during endoscopy with sedation,[66] but the incidence may be less in sedated than in unsedated patients[67]. Conversely, it has been shown that gastroscopy can

stimulate changes in blood pressure and heart rate that are more pronounced in sedated patients [68]. Using automated echocardiography, studies on healthy volunteers have shown an increase in cardiac stress during endoscopy. Further studies showed that this effect was unchanged in sedated patients.[69;70]

There are very few randomised controlled trials (RCT) comparing sedation versus no sedation in diagnostic endoscopy. There are no RCTs of this nature looking at therapeutic procedures. Clearly, recruitment to and avoiding bias in such trials is difficult with many patients having firm wishes to have, or not to have sedation. A small UK RCT looked at 100 patients randomised to sedation or no sedation for diagnostic upper gastrointestinal endoscopy. There were no adverse events in either group but non-sedated patients had a trend towards faster and easier procedures[71]. There are several studies looking at sedation free colonoscopy, where the need for sedation is perhaps less convincing than for upper gastrointestinal endoscopy. For example, a Norwegian study looked at 451 patients who had colonoscopy without sedation. 95% of participants found the procedure moderately uncomfortable (45%) or not uncomfortable (50%), the remaining 5% finding the procedure very uncomfortable. 90% of participants stated they would have a repeat procedure in another 5 years. However, the study group concluded that although feasible, unsedated colonoscopy may lead to longer procedure times, reduced caecal intubation rates and possibly higher miss rates for adenomas and cancers.[72] A Japanese group performed sedation free colonoscopy in 675 consecutive patients. 97.6% (659/675) of patients stated they had ‘no’ or ‘mild’ pain. This was corroborated by nurse assessment of pain where 98.8% (667/675) of patients had

nil or only mild pain during the procedure.[73] An American study concluded that unsedated colonoscopy should be at least offered to selected patients (older, male, absence of abdominal pain). This study suggested that not using sedation could save time and money both for the patient and healthcare provider.[74]

There are risks associated with the use of sedation in endoscopy and it has been shown that the rate of complications is higher in sedated patients. It has not been shown though that higher dose of sedation, or sedation alone is responsible for the worse outcomes. Other factors will confound and have been shown to predict poor outcome in endoscopy such as patient's age, ASA grade, inpatient status, and trainee participation[75]. Also, several studies have questioned the role of pharyngeal anaesthesia and use of other drugs such as hyoscine in complications at endoscopy[54;56;76].

We use sedation to make unpleasant healthcare procedures more acceptable to patients [77]. Randomised controlled trials have shown that sedation improves patient satisfaction with their endoscopy in terms of willingness to have a repeat procedure. It has also been shown that sedation improves endoscopists' satisfaction with the procedure and that procedures are more likely to be completed where sedation is used[78-80].

Current guidelines for the use of sedation in endoscopy, both in the UK and abroad, emphasize the risks of sedation, highlight the association between sedation and cardiorespiratory complications and recommend minimising the doses of sedation given, particularly when using a combination of agents and particularly in elderly patients[52;81-83]. The aim is to achieve a level of sedation adequate to ensure

tolerability, procedure completion and patient satisfaction whilst maintaining verbal contact and ensuring protective airway reflexes remain intact.

Sedation use varies around the world in terms of the types used and the amount. In some countries routine sedation is not the norm at all whereas in others full general anaesthesia is more frequently used. In the US 2,000,000,000 patients receive sedation for endoscopic procedures(ASGE)[84], or over 98% of patients undergoing gastroscopy or colonoscopy. In many European endoscopy units fewer than 25% of patients receive sedation for upper gastrointestinal endoscopy.[85;86] In Switzerland it is nearly 80%.[87] A study involving 14 centres in Norway showed a range of sedation rates from 6% to 97% of patients.[88]

Clearly sedation is not the only factor to influence outcome in GI endoscopy. The patient, the indication, the procedure type and therapeutic intervention will all influence outcomes and will each confound the other factors. The existing literature on sedation and endoscopic outcomes includes several prospective studies with only a few hundred participants. The largest randomised studies (at the time I started my MD) contained fewer than 500 patients[79] although there has since been a larger cohort study[89] looking at the effect of sedation on minor complications of colonoscopy. This contained over a thousand patients and concluded that sedation reduced the incidence of minor complications such as abdominal pain and distension post procedure. Of the non-randomised, prospective studies most contained only small numbers of patients with some notable exceptions. A large prospective audit of endoscopy outcomes including sedation use was carried out in the UK in the mid-1990s that included over 14,000 diagnostic and therapeutic (not

ERCP) upper endoscopy procedures[54]. This invited endoscopists to complete a questionnaire and report all adverse events for every procedure performed over a four month period. Self-reporting is likely to lead to underestimation which is acknowledged by the authors but the returns rate was high and a validation process suggested 95% accuracy and over 84% compliance. A more recent UK based study looked at colonoscopy outcomes following 9223 procedures[55]. Endoscopists were again asked to fill out a questionnaire for consecutive colonoscopies performed over a 4 month period.

The largest studies of endoscopy outcomes are retrospective studies. Many of these are survey based with questionnaires sent out to patients, endoscopists[56;87;90], endoscopy units[85] or national endoscopy societies[86]. Others made use of electronic databases[59;75;91]. The largest study was a survey published in 2009 by Baudet et al. This included 588,326 procedures performed at 197 units across Spain over 12 months. Questionnaires were sent out to each of 300 gastrointestinal endoscopy units rather than individual endoscopists. The study described the proportion of patients receiving any sedation rather than an exact dose but gives an illustration of the wide variation in sedation rates even within a single country. The largest of the database studies was published in 2007 and looked at cardiopulmonary complications following endoscopy[75]. It included 324,737 procedures, all performed under sedation, over 5 years. The database covered 81 endoscopy sites with 593 endoscopists across the United States. Units were based in university and non-university hospitals, as well as Veterans Administration Medical Centres. The reported complication rate was 1.4% overall and 0.9% for cardiopulmonary events.

The trigger for the single centre study described in the next section was the publication of the National Confidential Enquiry into Patient Outcomes and Death (NCEPOD) report 'Scoping our practice' in 2004. This made recommendations to minimise sedation use in an attempt to reduce deaths following endoscopy[92].

The group looked at 1818 deaths that occurred within 30-days of a therapeutic gastrointestinal endoscopic procedure. Cases were collected retrospectively and reviewed by an NCEPOD panel. All deaths occurring in hospital over a 12 month period were reported to NCEPOD by local reporters. The last 6 procedure codes for each case were identified from HES data. Where a procedure code identified a therapeutic endoscopy occurring within 30-days of death the case was included in the final study group.

The consensus opinion of this panel was that deaths were related to higher doses of sedation and poor patient selection – i.e. futile procedures. They concluded that 14% of patients that died were over-sedated. The NPSA bulletin and Lord et al report[93] (based on sub-analysis of the NCEPOD data and the East Anglia database), concluded that poor mortality outcomes were partly due to higher doses of sedation in the elderly, defined as patients over the age of seventy.

The NCEPOD report quoted overall figures for mortality after therapeutic endoscopy in 2002/2003, in England, of 3669 deaths in 128,563 patients (3%) according to data extracted from Hospital Episode Statistics. Recommendations were made and national guidelines issued requiring sedation doses to be reduced, particularly in the elderly. Other bodies such as the British Society for Gastroenterology (BSG), Royal College of Anaesthetists (RCA), National Patient

Safety Association (NPSA) have also issued guidelines to reduce sedation dosage. Endoscopy units in the UK are also now assessed using the Global Rating Scale (GRS). This includes quality and safety indicators and auditable outcome standards for endoscopy units including sedation use[81].

The NCEPOD report 'Scoping our Practice' does have limitations. Only deaths occurring in hospital were identified. Patients who died at home were not included. The NCEPOD report looked only at those who died. It did not look at the majority of patients who survived their procedure. It may be that the population who died differed in some significant way to those patients who survived that had nothing to do with their sedation. HES (Hospital Episode Statistics) data include only hospital inpatients. Therefore any patients who were designated 'outpatients' for their endoscopy would not have been reported in the HES data and therefore not included in the NCEPOD data. Clearly this could lead to overestimation of mortality as the population studied was restricted to those that had their procedure and died in hospital suggesting that they are a 'sicker' population than those who were designated outpatients and/or died at home. Whether procedures are coded as occurring in an 'outpatient' or as 'day case' (and therefore included in HES data) is dependent on local practice. As HES data forms the basis of tariff calculations and therefore income, hospitals are increasingly coding all endoscopy as day case procedures.

After the NCEPOD recommendations were published I became involved in an audit of current Endoscopy practice at a single UK centre; University Hospital Aintree in Liverpool[94]. Aintree is a large teaching hospital serving a local population of about

330,000 people. The Digestive Diseases Centre is one of the busiest in the country performing some 14,500 gastrointestinal endoscopic procedures each year including tertiary referrals. This gave us the opportunity to audit a much larger number of patients than had been studied in the majority of previously published work on endoscopic outcomes. We looked at overall outcomes of mortality and morbidity and a number of factors that might affect outcomes, including sedation use.

## Methods

The aims of this audit were based on the hypothesis that adherence to endoscopy guidelines would improve sedation practice which, in turn, would result in better endoscopic outcomes. We assessed baseline endoscopy performance for workload, complications and mortality, introduced improvements in practice according to guidelines and then attempted to measure change in outcomes.

Cases were identified retrospectively from 'Endoscribe', the unit's electronic database used at the time to record all endoscopies performed within the endoscopy unit. All endoscopic procedures except ERCP performed within a predetermined 6 month period were identified and details from the endoscopy report entered into a separate Access database. ERCP procedures were not included as they were the subject of a separate audit. Patients younger than 16 years of age were excluded as were any procedures performed under general anaesthesia. Additional patient information and their alive/dead status were extracted from the hospital Patient Administration System (PAS), and case notes. The main outcomes measured were: mortality within 30-days of the procedure, sedation type and quantity, use of reversal agents, adverse events and patient procedure tolerance. Routine demographic information about the patient, grade of endoscopist and the procedure type were documented.

Following this audit, changes in local practice were implemented in light of the NCEPOD report, BSG guidelines and the national endoscopy team guidance (Global rating scale quality indicators). The changes made were:

i. Creation of a multidisciplinary Endoscopy Steering Group

ii. Introduction of a unit sedation policy

iii. Pre-filled, pre-packed syringes containing 5mg midazolam supplied by Pharmacy to encourage adherence to guidelines (no more than 5mg midazolam to be given in one procedure)

iv. Adverse event logbooks introduced into each theatre

v. Regular audit of adverse events with dissemination of results to all endoscopy unit staff. (Use of more than 5mg of midazolam in a single procedure was deemed to be an adverse event)

Fifteen months after the implementation of the above measures the audit was repeated. Again this was a retrospective analysis of 6 months of endoscopy at Aintree including all endoscopic procedures except ERCP and procedures performed under general anaesthetic. Those under 16 years of age were again excluded. Cases were again identified using an electronic endoscopy database. Findings from the two audits were compared to assess if the changes in practice had brought about improvements in outcomes.

Following the first audit the endoscopy unit updated its electronic database to one with in-built audit facilities. This helped to improve data collection and analysis as it saved us having to print off each individual endoscopy report and re-entering data into a new database.

### Statistical analysis

Sedation doses were compared using non-parametric statistical methods (Mann-Whitney U). Adverse outcome rates were compared using Chi-squared test. Significance levels were set at $p < 0.05$.

## Results

In 2004 a total 7234 procedures were identified in 5999 patients. In 2006 the total number of procedures was 7071 in 5946 patients.

Patient demographics from the two audit years were very similar (Table 2.1), as were the procedure types performed and the designation of the endscopist (Figures 2.1 and 2.2). The mean age of the patients in group 1 (2004) was 59.6% and was 60.4% in group 2 (2006). Midazolam was given in 53.5% and 56% of patients respectively. Diagnostic gastroscopy made up just over 50% of procedures in both groups, with therapeutic procedures forming 8-9% of the workload. There were 32 endoscopists working in the unit in 2004 and 38 in 2006. Of the 48 endoscopists working in the unit during the audit period, 22 (46%) endoscopists worked in the unit over both years. This included all the nurse endoscopists, staff grades and most of the surgical and gastroenterology consultants i.e. the majority of the workload for both years.

**Table 2.1 Patient populations for 2004 and 2006**

| | **2004** | **2006** |
|---|---|---|
| Number of procedures | 7234 | 7071 |
| Mean age (years) | 59.6 | 60.4 |
| Mean age of deceased (years) | 74.3 | 74.5 |
| Proportion sedated (%) | 53 | 56 |

**Figure 2.1 Proportion of specific endoscopy procedures for each audit period**

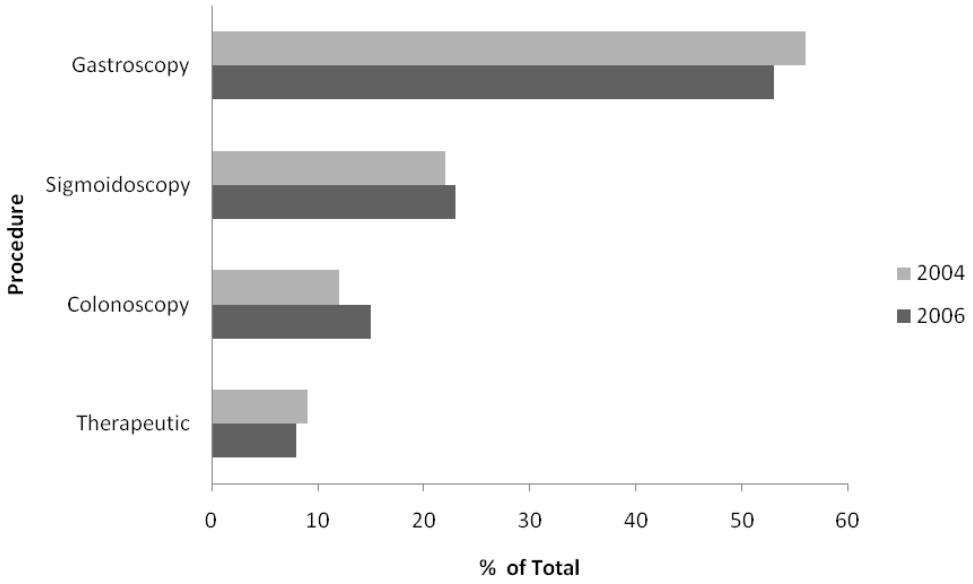



**Figure 2.2 Workload by endoscopist type**

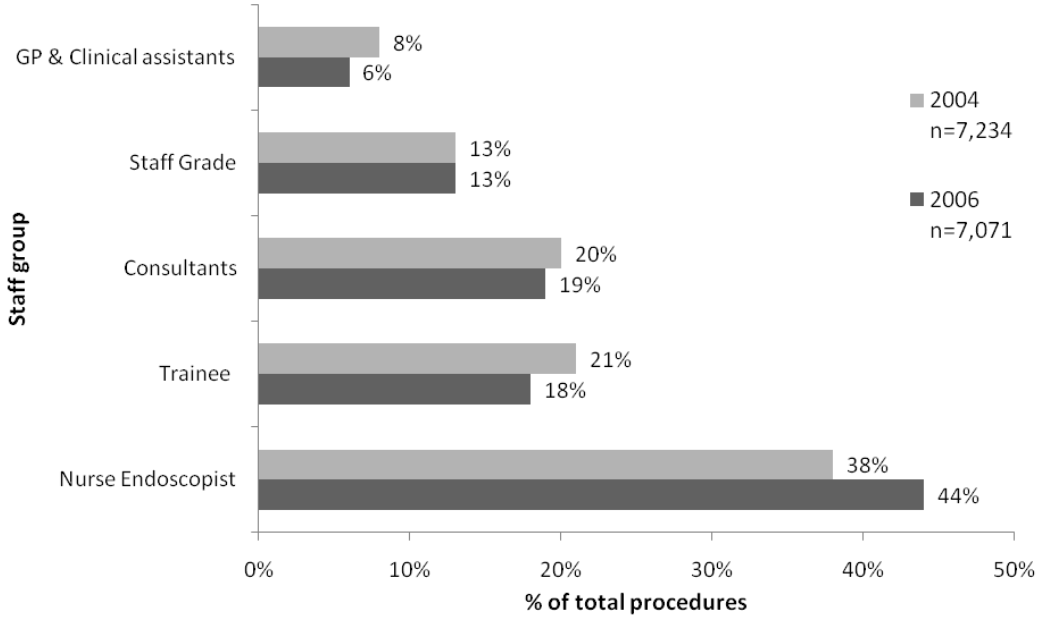
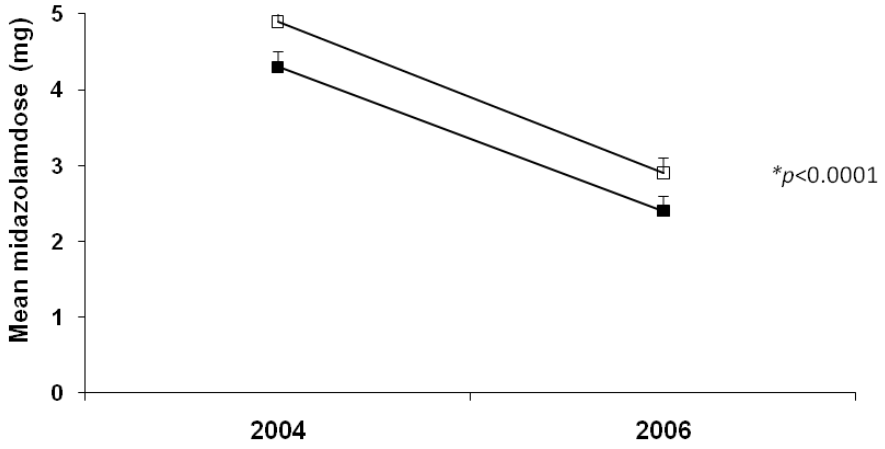
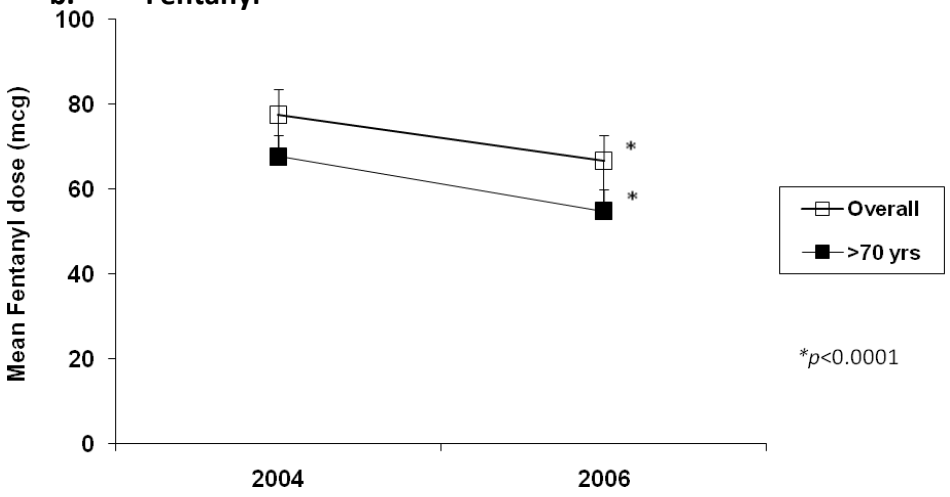


**Figure 2.3 a-c Reduction in sedation doses from 2004 to 2006**

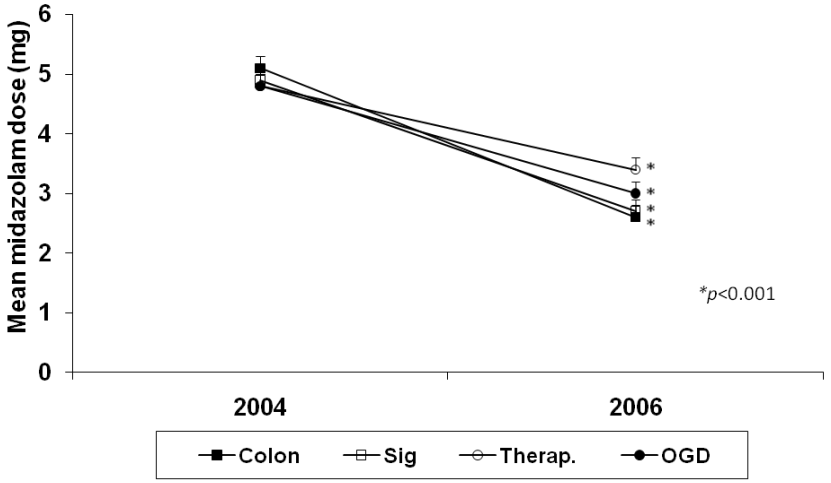
**a. Midazolam**




**b. Fentanyl**



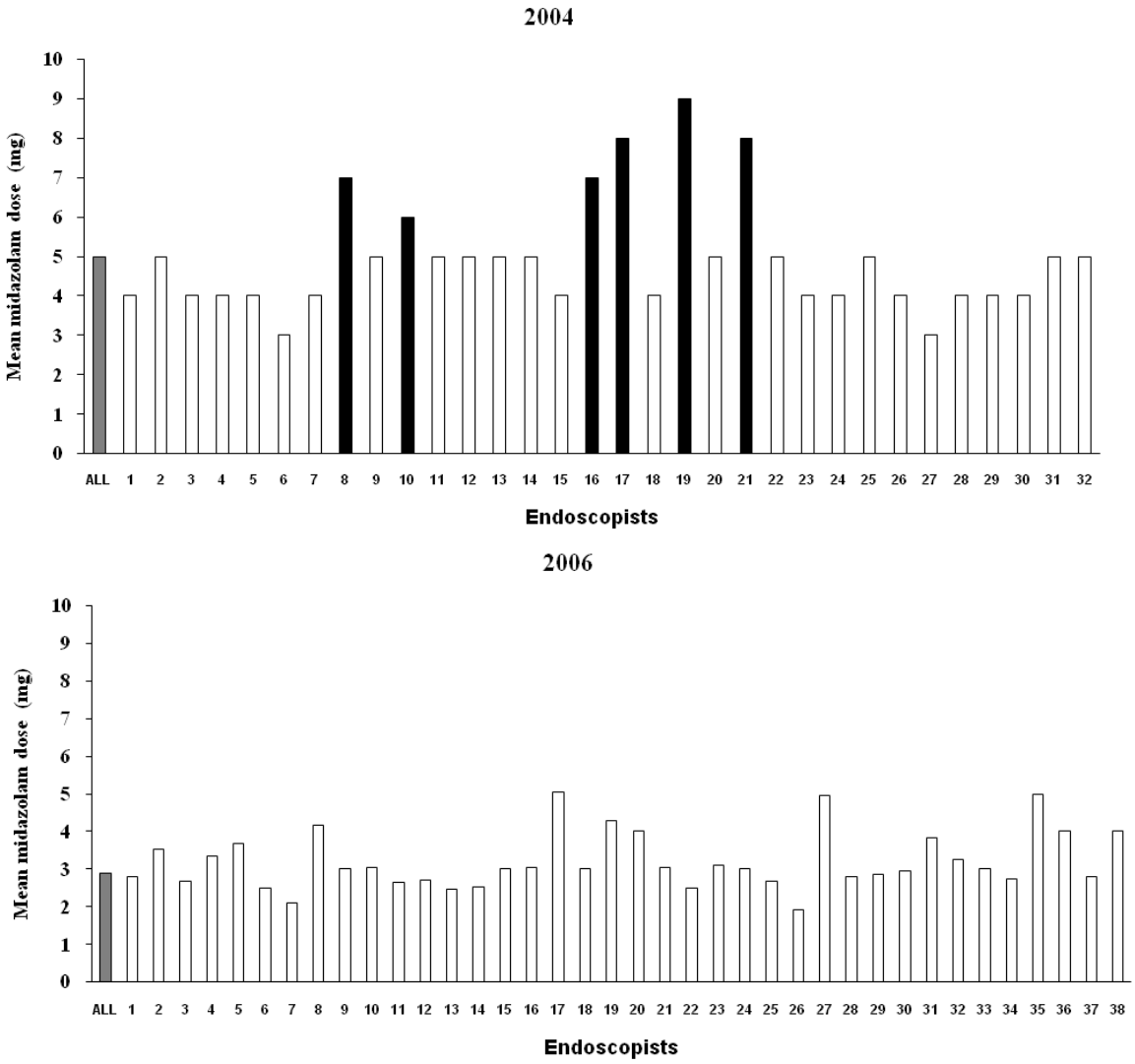

**c. Midazolam dose reduction by procedure type**



Sedation doses fell from the first to the second year with an overall mean midazolam dose in 2004 of 4.9mg (SD=2.5mg) and a mean of 2.9mg (1.2) in 2006 ($p$<0.0001) (Figure 2.3). The reduction in mean midazolam dose was also seen when looking at just those patients over 70 years of age with a fall from 4.3mg (2) to 2.4mg (1) ($p$<0.0001). A reduction in mean midazolam dose was seen in all procedure types included in this study. Mean fentanyl doses also fell across the two study periods from 77mcg (SD=38.5) to 66.7mcg (27) ($p$<0.001) and in patients over 70 years old from 67.7mcg (46) to 54.8mcg in 2006 ($p$<0.0001).

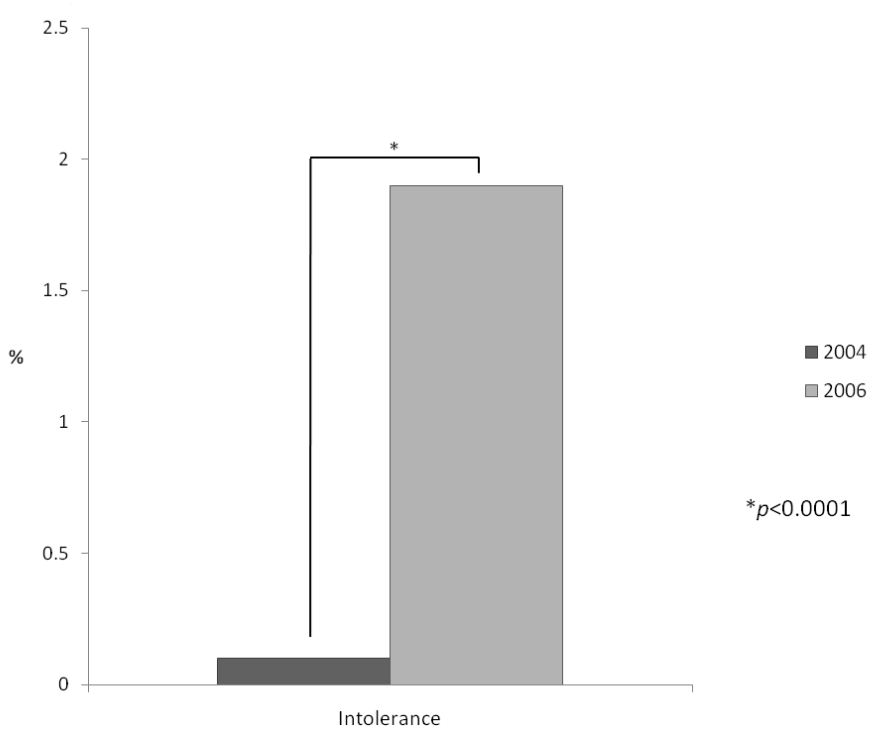
In 2004 19% of unit endoscopists were using a mean of greater than 5mg midazolam. In 2006 none of the endoscopists had a mean midazolam use of greater than 5mg (p=0.005). Anonymised results for each individual are shown in Figure 2.4.

**Figure 2.4 Mean midazolam dose given by individual endoscopist. Grey columns indicate unit average; black columns indicate mean midazolam dose over 5mg**



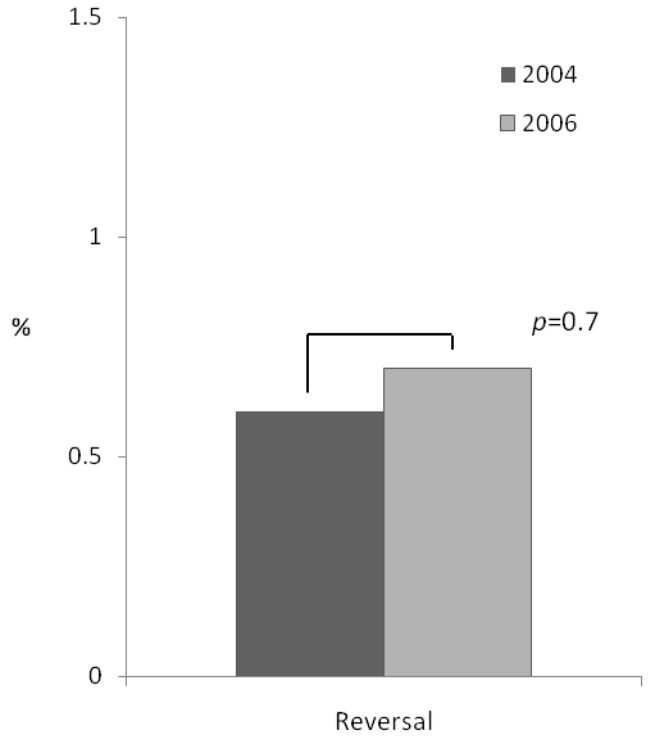
The absolute number of procedures that were unsuccessful due to patient intolerance was small in both years but there was still a significant increase in the rate in the second year of analysis; 0.1% in year one and 1.9% in year two ($p$<0.0001). (See Figure 2.5)

**Figure 2.5 Percentage of procedures that was unsuccessful due to patient intolerance**




Reversal agents are used to reverse the effect of a sedating medication where a patient has inadvertently become over-sedated and there is a risk to the patient's ability to breathe and protect their own airway. It is generally used as an emergency measure rather than as a planned medication to 'allow' larger doses of sedation to be given. The use of the reversal agents flumazanil (to counteract benzodiazepines including midazolam) and naloxone (to reverse the effects of opiates including fentanyl) did not change over the two study periods with a rate of 0.6% of procedures in 2004 and 0.7% in 2006 ($p$=0.74). (Fig.2.6)

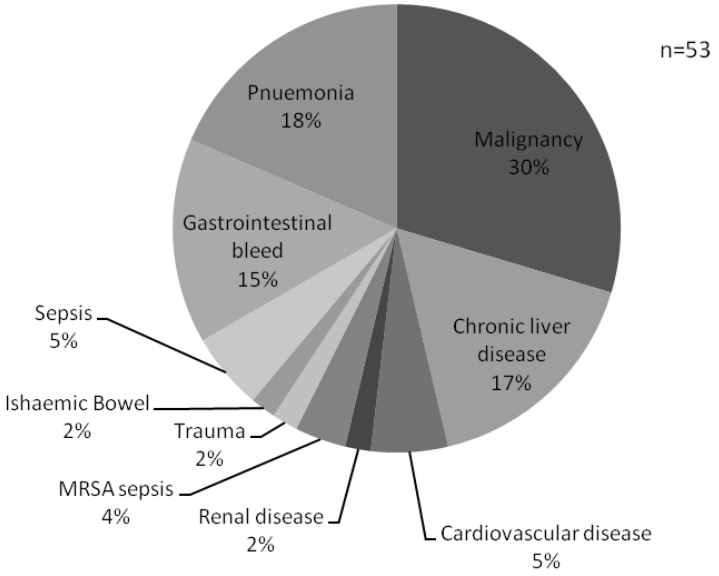
**Figure 2.6 Percentage of procedures where reversal of sedation occurred**



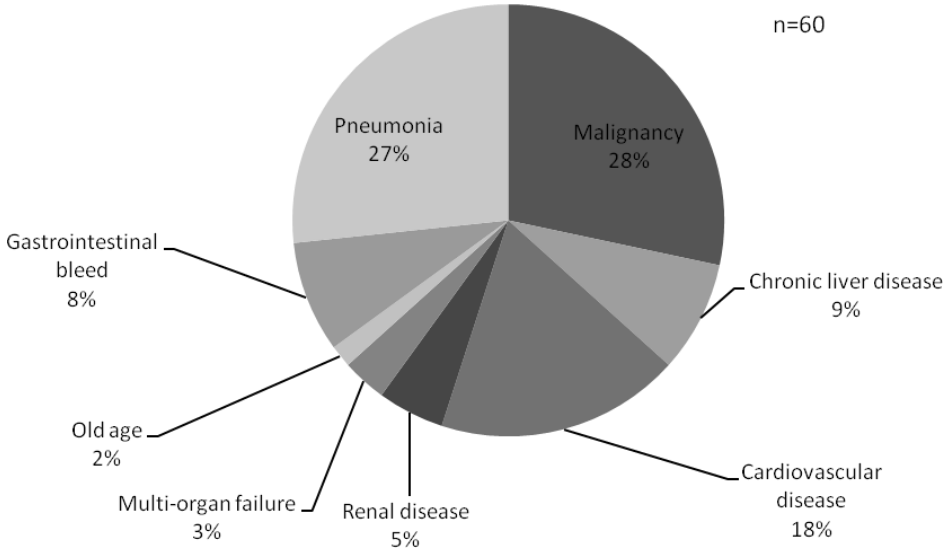

All deaths within 30-days of endoscopy were subject to full case note review and review of death certification to ascertain the cause of death and to allow some judgement as to whether the endoscopy procedure contributed to or was the cause of death. Although all points on the death certificate were assessed the diagnosis documented in part 1a of the death certificate was the one used for the following analysis. Pneumonia (18% in 2004, 27% in 2006), malignancy (29%, 29%), cardiovascular disease (6%, 18%), chronic liver disease (16%, 8%) and gastrointestinal bleed (15%, 8%) covered the majority (over 80%) of the 30-day deaths following endoscopic procedures for both years (Fig. 2.7a&b).

**Figures 2.7 a+b Primary diagnosis as stated on death certificate for deaths within 30-days of endoscopy - 2004 and 2006**

**a. 2004**

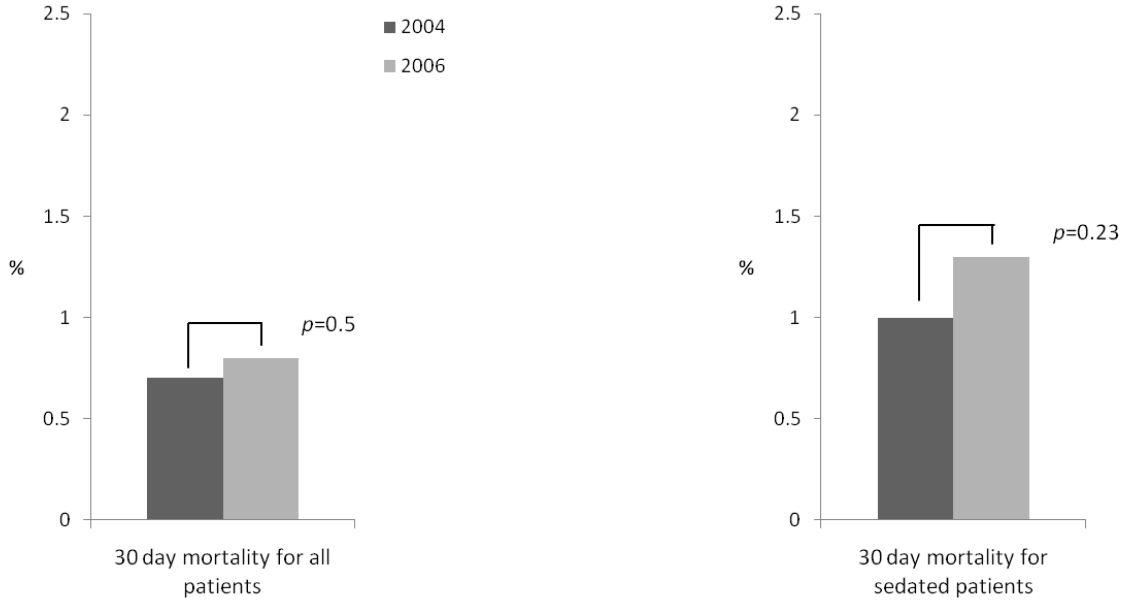



**b. 2006**



The absolute number of 30-day deaths was small; 53 individuals in 2004 and 60 in 2006. This gave an overall 30-day death rate that was unchanged across the two data periods of 0.7% and 0.8% ($p$=0.5). Mortality among just the sedated patients was similar across both datasets 1% and 1.3% ($p$=0.23) with the mortality rate for un-sedated patients significantly lower for each dataset; 0.5% in 2004 ($p$=0.01) and 0.35% in 2006 ($p$<0.0001). (Fig 2.8)

**Figure 2.8 All-cause mortality rates within 30-days of endoscopy 2004 & 2006**




Looking at just those patients who died the mean age of these individuals was 73.3 years (SD=17) in 2004 and 74.5 years (12) in 2006. There was an increase in the proportion of these patients who had received sedation from 70% to 82% (37/53 in 2004, 49/60 in 2006). The dose of midazolam received by patients who died within 30-days of a procedure was significantly lower than the overall mean midazolam dose given to patients in each dataset. In 2004 patients who died received a mean midazolam dose of 3.5mg (SD=1.8) compared to an overall mean midazolam dose of 4.9mg (2.5) ($p$<0.0001). In 2006 the mean midazolam dose was 1.96mg (1.3) in

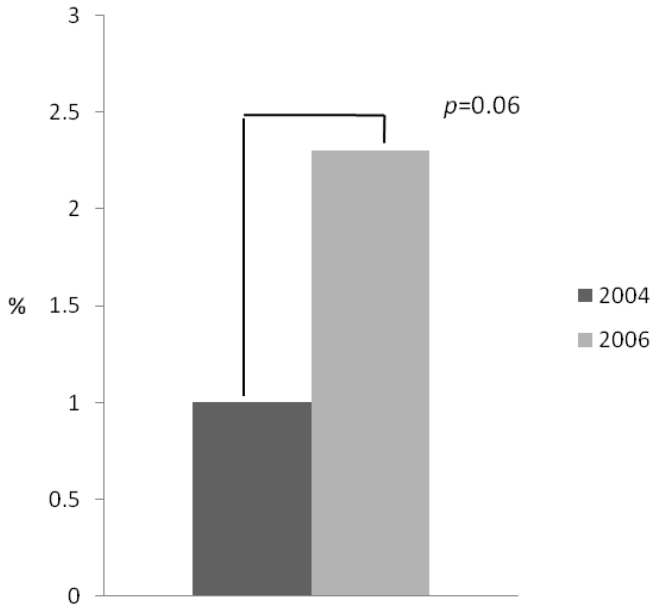
those patients who died within 30-days of their procedure compared to a mean of 2.9mg (1.1) given to those patients who were still alive at 30-days following their procedure ($p$<0.0001). The reduction in midazolam dose from 2004 to 2006 maintained significance when looking at just those patients who died within 30-days of the endoscopic procedure ($p$<0.0001).

We performed a sub-analysis of those patients who were over 70 years of age at the time of endoscopy. Of those aged over 70 that received sedation, 30-day mortality was 2.7% in 2004 and 4.1% in 2006 ($p$=0.06). Guidelines suggest that sedation doses should be reduced in the elderly and if we compare those elderly patients receiving more than 2mg of midazolam to those that received up to 2mg midazolam we find that 30-day mortality was higher in the group receiving more than 2mg of midazolam. This was statistically significant in 2006 (3% vs. 1.2%, $p$=0.01) but not in 2004 (1.8% vs. 0.9% $p$=0.22). However, if data was combined for both years significance was lost: 30-day mortality in those aged over 70 receiving more than 2mg of midazolam was 2.3%, compared to 1% in those receiving a maximum of 2mg midazolam ($p$=0.5). (Figure 2.9a & b)

The rate of overall adverse events (death, immediate complications, use of reversal agent) did not change from the first audit to the next (1.7% to 2%. $p$=0.44) (Figure 2.10). Additionally, in the first audit, we looked at total adverse event rate for those receiving up to 5mg midazolam sedation and those receiving more than 5mg of midazolam and found no significant increase in the number of adverse events (1.0% and 1.4%, $p$=0.4).

**Figures 2.9 a +b Mortality in patient over 70 years of age**

**a. Overall mortality**




Overall 30 day mortality for patients over 70 years old

**b. Comparison of mortality for high and low dose midazolam in those over 70 years old**

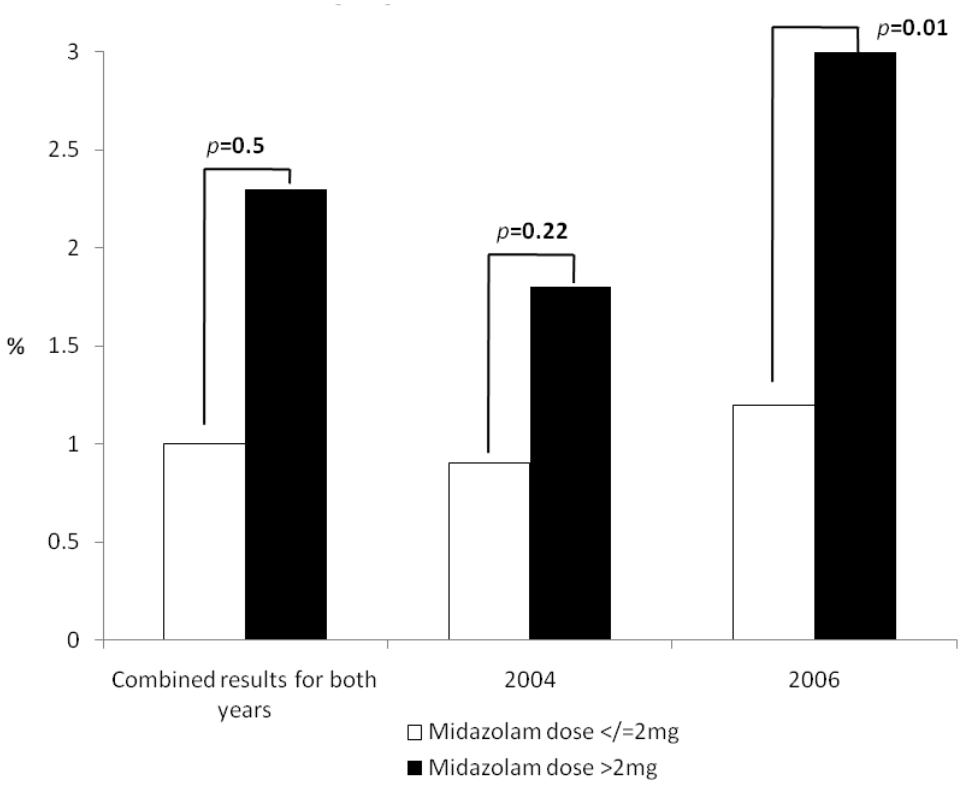
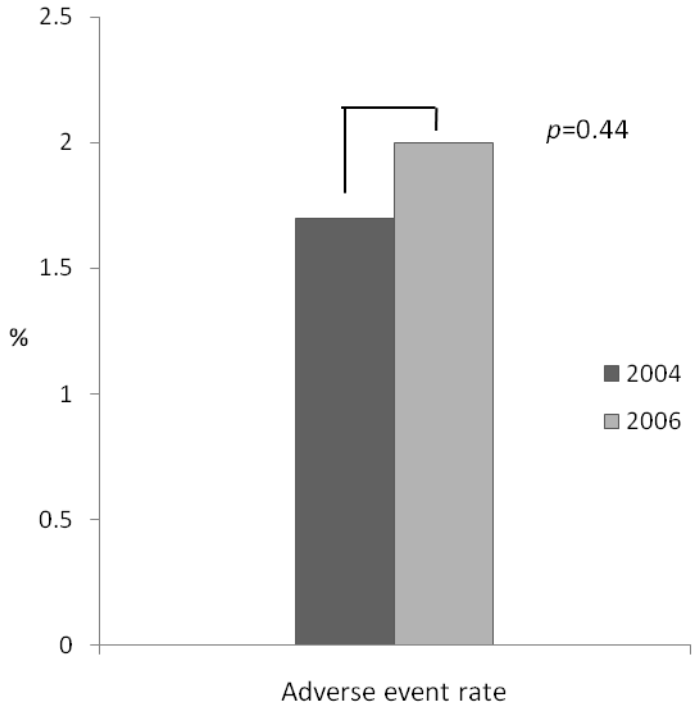


**Figure 2.10 Overall rates of adverse events (death, immediate complications and use of reversal agents**



## Discussion

Despite achieving significant improvements in practice, particularly sedation dose, these improvements did not translate into improved outcomes in terms of mortality, complications or patient satisfaction. Indeed lower sedation doses may have had a deleterious effect on outcome.

There are no conclusive studies in the literature showing that higher doses of sedation or indeed, sedation alone, are responsible for worse outcomes following endoscopy. Mortality and morbidity associated with these procedures is likely to be multi-factorial in aetiology. Overall, the Aintree study did not show significant changes in mortality despite showing clear reductions in sedation dose and improved performance. Patients given over 5mg of midazolam and therefore 'over-sedated' by BSG and RCA recommendations did not have worse outcomes. Improved performance as judged by adherence to sedation guidelines was seen in the second year of analysis, with no endoscopists using a mean dose of midazolam greater than 5mg, but measured outcomes did not improve.

Interestingly, the mean dose of midazolam used in patients who died within 30 days of their procedure was lower than the overall mean dose used in both years of study. The mean dose amongst this group of patients was also lower in 2006 than in 2004. The average age of patients who died was over 70 and the mortality rate amongst older (over 70 years of age) patients was higher in the second year of analysis. This is suggestive, but by no means conclusive of, reduced sedation doses having a negative effect on mortality in this group of patients. Conversely, sub-analysis of all patients over the age of seventy in the Aintree study showed a doubling of mortality in those receiving greater than 2mg of midazolam compared

to those receiving less than or equal to 2mg. This was not statistically significant and numbers were very small making the validity of these findings somewhat debatable.

This was a large in-house audit using a local, clinical database. Capture of cases was felt to be complete. Most, if not all cases performed in theatres or intensive care were captured and the number of cases not entered into the electronic reporting system due to system failure would have been negligible. However, the project was time consuming and labour intensive. This did improve substantially in the second round of audit with the introduction of an electronic endoscopy reporting system that had basic audit facilities.

There are several limitations to the Aintree study which must be taken into account when interpreting its conclusions. A large randomised control trial of sedation versus no sedation in age, disease and procedure matched cases would provide more robust results but would be almost impossible to do. Particularly in therapeutic endoscopic procedures, restricting sedation would be unethical. Patients who agree to have procedures without sedation may have many different reasons for that decision and may be selecting themselves out as a 'different' population to those that choose to have sedation.

Adverse events in endoscopy are rare. The maximum adverse event rate was 2% in the Aintree study, looking at over 14,000 procedures. Thus despite having a very large 'sample' size it may still not be adequate to detect differences as the event rate is so low . However, our event rates were in keeping with those found by NCEPOD and other studies. The trend towards worse outcomes in the second year

of study, rather than the expected improvement, would also seem to make a Type 2 error less likely.

Although large, this audit was performed in a single centre. Single centre studies are often criticised due to the potential for selection bias and as George Gallup (of 'Gallup polls') realised in the 1930's [95], simply having a very large sample does not negate this risk. However, with the Aintree study it was felt that findings were still representative of current endoscopy practice across the UK due to the large number and variety of cases studied and the number of endoscopists involved. In particular, that the endoscopists were from a range of medical, surgical and nursing backgrounds and their endoscopy experience was wide-ranging, with a number of the endoscopists still in training.

Determining cause of death retrospectively is difficult even with access to full case-notes. Deciding if a death is directly due to a procedure, rather than progression of underlying disease or coincidence, can be a very subjective decision. Inter-observer variability in the interpretation of a case could lead to bias. In any group of deaths following a medical or surgical procedure there will be a group of deaths that are clearly not related to the procedure and some deaths that definitely are related to the procedure or a complication thereof. However, there will be a large group of deaths that could be a result of the procedure and therefore potentially avoidable but equally could have happened anyway. Some studies have attempted to provide a clearer causal relationship by grading deaths. For example, deaths definitely caused by the procedure, probable cause, possible cause, probably not cause, definitely not cause. The use of all-cause post procedure mortality within 30 days

of an endoscopic procedure in the Aintree study was felt to be the pragmatic solution to this problem.

The outcome measures used in the Aintree study were limited to hard-endpoints that were relatively easy to assess from the endoscopy reports and hospital patient administration system. Again this was a pragmatic approach when looking at a large number of cases but the lack of clinical depth is a weakness of the study. Patient status at time of endoscopy in terms of ASA grade for example was not possible to assess in the first year of the study. Repeat procedures were not highlighted nor their outcomes compared to solitary procedures. The procedure indication, primary diagnosis, co-morbid diagnoses, length of stay in hospital after procedure, readmission rate, patient satisfaction with procedure, details of late procedure complications are all factors that are important in assessing outcomes in endoscopy but were not included in this study. This was a retrospective study and assessing for all confounding factors in endoscopy outcomes would require many more man hours and access to all patient case notes. The study did take a relatively long time which could be a weakness in terms of its relevance to current practice. However, sedation use and measurement of outcomes in endoscopy continues to be very topical.

Case notes were studied for all deaths as were the death certificates. However, there are many studies showing that death certification is not always accurate[96-102].

There have been many studies on the physiological changes that occur during endoscopy which may provide some scientific basis to different rates of adverse

outcome in endoscopy[69;103-116]. That sort of analysis was not within the remits of the Aintree study which was primarily a clinical audit.

Despite these concerns the study had many strong points. The reproducibility of population characteristics over the two years is reassuring and adds to the validity of the study findings. It is one of the largest studies in this area, certainly in the UK. The mortality rate was consistent with other studies such as NCEPOD (1,818 deaths out of 136,000 procedures assessed is a mortality rate of 1.3%). The study looked at all patients undergoing endoscopy rather than just those that died or sustained complications. This provides a more balanced and honest view of endoscopy outcomes. The significant drop in sedation use following the introduction of a sedation policy was convincing, with a 40% reduction. Although the methods for assessing patient tolerance in the Aintree study were fairly crude, the rise in incomplete procedures due to patient intolerance has been shown in other studies[71;78-80].

## Conclusion

Adverse outcomes and mortality are rare events in endoscopy. Poor outcomes are likely to have multi-factorial causes which may include 'under' or 'over-sedation'. However, it is likely that outcome is largely determined by the patient's pre-existing diagnoses and risk profile, rather than by the procedure itself. For example, a patient with oxygen dependent chronic obstructive pulmonary disease who is admitted with a significant gastrointestinal bleed is likely to have a greater risk of poor outcome following gastroscopy than a 21 year old otherwise fit and well man who has an elective gastroscopy to investigate reflux symptoms. The procedure is not the main determinant of outcome.

Complications in endoscopy are rare events. Large numbers of cases are therefore needed in any study of endoscopy outcomes to reduce the occurrence of a type 2 error. Prospective studies of this size are difficult to achieve. Questionnaires can lead to recall bias and subjective interpretation of events. The use of sedation will itself contribute to recall bias! Endoscopy datasets allow large numbers to be studied but still may only represent a subsection of a population. The data sets rely on accurate, consistent data entry. Improvements in electronic reporting systems for endoscopy with more sophisticated, real-time recording of patient status at endoscopy and the ability to add in early and late complications linked to wider hospital administrative databases will allow a more realistic assessment of outcome and risk.

Overall this large internal audit provided evidence to guide sedation use that is useful at both a local and national level. The latter because of the very large numbers involved. However, with current endoscopy reporting systems this would not be a process that could be repeated easily on a regular basis to monitor performance over time. Audit cycles are generally repeated annually or biannually. On this scale a permanent team of administrators would be required to collect and analyse the data.

Thus it is hypothesised that using an administrative dataset such as HES to assess outcomes following endoscopy would be preferable to analysing a clinical dataset as was done here. Administrative datasets would allow consistent, reproducible analysis of large numbers of cases. This is particularly useful where an outcome, death, is such a rare occurrence.

# 3. Endoscopic Retrograde Cholangio-Pancreatography

# 3. ERCP


## Abstract

***Background and aims:*** In selecting patients for ERCP, clinicians must balance the benefits of intervention versus disease prognosis, co-morbid conditions and procedural risks.

The primary aim of this study was to explore the potential for using routinely collected Hospital Episode Statistics linked to death registry information to generate estimates of mortality in patients requiring ERCP in England and to identify simple predictors of outcome. Our secondary aim was to analyse variation in crude 30-day mortality statistics at institutional level. A key component of the study was to engage with front-line teams in order to better understand issues of data quality, appropriate clinical interpretation and to demonstrate the value of measuring post-ERCP mortality from routine hospital coding.

***Methods:*** We obtained HES data for two consecutive data years: 1st April – 31st March 2006/07 and 1st April – 31st March 2007/08. From these master datasets we extracted all episodes of care containing ERCP procedures. Mortality outcomes were assigned to each case by linkage to the Office of National Statistics Death Registry.

ERCP episodes were analysed for demographics, admission method, diagnoses and co-morbidity and last-coded diagnosis before death. Factors associated with death within 30 days of ERCP procedure were identified by univariate and multiple logistic analyses. Crude and case-mix adjusted mortality were analysed at institutional level.

Preliminary data outputs were shared with front-line clinicians and feedback led to refinement of the original study with final analysis using data for first ERCP rather than last ERCP.

***Results:*** The raw HES data contained 10,753,151 episodes of care for 2006/07 and 11,296,023 episodes for 2007/08. Following data cleaning a study population of 20,246 patients for 2006 to 2007 and 20,692 for 2007 to 2008 was extracted.

ICD-10 codes contained within each ERCP episode were categorised according to diagnosis with 57.3% relating to gallstones, 12.6% cancer, 2% gallstones and cancer and other diagnoses in 28.1%. All-cause 30-day mortality rate was 5.3%. The mortality rate in patients with no cancer diagnosis was 2.4%.

Binary logistic regression analysis of the 2006/07 data set confirmed age, sex, emergency admission, and cancer and non-cancer co-morbidity as independent predictors of 30-day death. Adjusted odds ratios for mortality were 6.2 for age ≥85 yrs v <55 yrs; for male sex 1.2 v female; emergency admission 2.0 v elective; cancer 8.6 v no cancer and non-cancer co-morbidity 1.5 v no co-morbidity.

Specific procedural complication codes were found in 1.2% of deaths (0.06% of ERCPs). At institutional level, mortality rates were within expected statistical limits and regression analysis showed no significant trend between procedure volume and all-cause mortality risk at 30 days ($r=-0.05$; $p>0.05$; $n=150$ Trusts).

***Conclusions*:** All-cause mortality after ERCP is largely explained by the natural history of underlying disease. Much of the early mortality occurs in older, acutely unwell (emergency) patients with co-morbid medical conditions and underlying cancer. Administrative, routinely collected data allows robust analysis of mortality after ERCP at a national level.

## Introduction

Endoscopic retrograde cholangiopancreatography (ERCP) is an advanced and challenging endoscopic technique that plays a vital role in the management of benign and malignant pancreatic and biliary diseases. Its use as a diagnostic procedure has diminished with the increasing availability of alternative, less invasive diagnostic modalities such as MRCP and EUS.[117]

In selecting patients for ERCP, clinicians must balance the benefits of intervention versus disease prognosis, co-morbid conditions and procedural risks. Complications such as pancreatitis, sepsis, bleeding or perforation occur in 5-10%.[118] The independent UK report published by NCEPOD in 2004 examined 237 deaths within 30 days of ERCP and concluded that death was a 'definite risk' or 'expected' risk in 69% of cases and that most mortality reflected the progression of underlying disease (e.g. malignancy). However, the report suggested that ERCP was 'futile' in 68% of deaths and made a number of recommendations aimed at optimising patient selection and pre-procedure medical condition.[52]

Difficulties arise in interpreting results from these studies due to variations in how complications and adverse events are defined. For the American Society for Gastrointestinal Endoscopy (ASGE) a complication is "an adverse event that necessitates intervention". For other groups a complication is "any event occurring during the 30-day period after the procedure that changed the health status of a patient negatively for any length of time"[119]. Some define a complication as an adverse event that requires additional hospitalisation or readmission[120;121]. Cotton et al developed a grading system for complications following endoscopic

sphincterotomy which has been used by some but not all groups in subsequent studies to classify complications following ERCP generally and endoscopic sphincterotomy specifically[122]. Procedural failure rate and length of stay were used as outcome measures rather than specific complications by one American group[123]. Failed procedures were defined as the 'need to perform percutaneous transhepatic biliary drainage or open common bile duct exploration after ERCP'.

Overall complication rate for ERCP is generally quoted in the region of 5% and appears to have remained static over the last decade. However, figures vary widely from as low as 4% to as high as 15.9%[120;124-129]. Overall 30-day mortality ranges from 0.5% to 5.8%. These ranges may reflect differences in data collection, patient follow-up and definitions. Using telephone follow-up at 30 days in addition to case note review, one study increased its overall 30-day adverse event rate by 50%[126]. Some studies only recorded data up to the point of discharge[121]. This may explain their relatively low mortality of 0.12%, although their overall complication rate of 4.95% is in keeping with the 30-day figures from other studies.

The proportion of therapeutic procedures has increased over time with current practice guidelines suggest that over 90% of ERCPs should be of therapeutic intent and that therapy should be successful in more than 80% of attempts[128]. Therapeutic ERCP carries higher risks of complications and mortality than diagnostic ERCP. Several studies have shown almost double the rates of complications and mortality in therapeutic procedures compared to diagnostic[121;124;125;130]. Of note, the 'Barthet' study defined a complication as any adverse event that required more than one night of hospitalisation. This single centre study of 1159 ERCP procedures had a

complication rate for endoscopic sphincterotomy of nearly 8% by this definition. One single centre, prospective study found that diagnostic procedure was a significant risk for complications in univariate analysis[119]. This study, as with many others had much lower rates of therapeutic ERCP than is recommended. Christensen et al looked prospectively at 1177 ERCPs performed over 2 years, in one tertiary centre. Only 56.2% were therapeutic. It is also noteworthy that their success at selective duct cannulation was only 63% for bile duct opacification. Successful duct opacification should occur in greater than 80%[131;132]. Three of their thirteen endoscopists had performed fewer than 100 ERCPs prior to the study, yet performed over 10% of the final number. Despite this there was no difference in complication rates between less experienced and highly experienced endoscopists. The overall complication rate was 15.9% with a 30-day mortality of 5.8%.

Studies looking at ERCP outcomes are small in number. Many are single centre studies looking at a few hundred procedures. Even the largest prospective, multicentre studies generally identified fewer than 6000 which is a small proportion of the total performed in a single country. For example, it is estimated that 48 000 ERCPs are performed each year in the UK, yet the largest study to date of UK ERCP was a multi-centre study that identified just 5264 procedures over a 6 month period[133]. The number of cases identified by each centre in this study also varied from single figures to almost 300. Even accounting for non-consenting patients these figures may not be representative of all patients undergoing ERCP in the UK.

One of the largest studies of ERCP outcomes was conducted by an American group from Birmingham, Alabama and published in 2006. They used a US national hospital

administrative database of inpatients (similar to the HES database) to analyse 199,625 ERCPs in 1662 hospitals over 4 years. The number of procedures performed in each hospital ranged from 1 to 1004 in 12 months. The group used logistic and multiple regression to show an association between procedure volume and ERCP outcomes: an increased length of stay and higher rate of failed procedures was associated with a smaller volume whereas no effect was seen on inpatient mortality [123]. However, high volume institutions were defined as performing 200 or more ERCP procedures in 12 months which accounted for only 5% of all the centres included in the study. The median number of ERCPs performed was 49 and only 25% of hospitals performed over 100 procedures in a year. It may be that results from the very low volume centres (fewer than 50 ERCPs a year for example) may have 'obscured' results from those hospitals performing 100 to 200 procedures a year that would compare well to those (presumably tertiary) centres with the highest procedure volume. Although odds ratios for mortality and failed ERCP procedures were provided for a number of variables, absolute mortality rates were not provided in this study.

Many studies are based in tertiary centres where case and skills mix will differ from smaller hospitals. One multi-centre study showed significant differences between tertiary and other hospitals for rates and indications for biliary sphincterotomy, pancreatic sphincterotomy and pre-cut papillotomy[134].

Endoscopy units in the UK are encouraged to audit 30-day mortality as part of the accreditation and quality assurance program [135] but the NHS lacks systems that can capture all procedures and link to subsequent outcome. Hence, expected levels of

mortality for unselected cohorts of patients requiring ERCP are poorly defined. A voluntary survey of 66 English hospitals reported an all-cause mortality rate of 2.7% within 30 days of first ERCP but procedural-related death rate was low at just 0.4%.[129] However, this study covered fewer than half of institutions and each hospital captured only a sample of total workload. Knowledge of real-world mortality risk for patients requiring ERCP for specific indications is limited and better understanding of the predictors of survival would help inform the process of case-selection and patient consent. Disclosure of risks to patients requiring ERCP has been shown to be inconsistent both in the UK and in other countries[136;137]and a common theme in litigation claims after poor outcome.[138]

When studying relatively uncommon events and with so many variables involved, as with the sedation studies discussed in the first chapter, prospective studies can become unwieldy and prohibitively labour-intensive. Although clinical depth may be somewhat limited, pre-existing administrative datasets, such as HES, do give access to huge numbers of cases that can give more robust outcomes data, in terms of providing adequate power for statistical analysis.

The primary aim of this study was to explore the potential for using routinely collected Hospital Episode Statistics linked to death registry information to generate estimates of mortality in patients requiring ERCP in England and to identify simple predictors of outcome. These data were used to produce a bedside tool for estimating all-cause mortality risk. Our secondary aim was to analyse variation in crude 30-day mortality statistics at institutional level. A key component of the study was to engage with front-line teams in order to better understand issues of data

quality, appropriate clinical interpretation and the value of measuring post-ERCP mortality from routine hospital coding.

## Methods

We obtained HES datasets in SPSS format for two consecutive data years: 1st April – 31st March 2006/07 and 1st April – 31st March 2008/9. (Provided by Northgate Information Solutions[139].) Each 12-month dataset contains around 15 million episodes of inpatient care from NHS hospitals in England. Our aim was to create a master dataset for each year containing all episodes of adult, inpatient care, within specified specialities, carried out in NHS acute Trusts in England from 1st April 2006 to 31st March 2008.

From these master datasets we then extracted all episodes of care containing ERCP procedures. These episodes were then held in new ERCP datasets for further analysis. Where a patient had more than one ERCP episode we identified the order of episodes, particularly the first and last episodes. Each episode contains a number of codes describing diagnoses, procedures and demographic detail. From these codes further categorical variables were added to describe ERCP indication and the patients' health status in terms of co-morbidity and age. Each episode has a mortality outcome assigned to it at 7 and 30 days. This was achieved by linkage to the Office of National Statistics Death Registry.

Below we describe the methodology of extracting the episodes of interest from the 'raw' HES data and creating datasets of ERCP procedures. The specific syntax used within SPSS to perform each data extraction and subsequent analysis can be found in Appendix 7.1.

## The Master Datasets

Each episode of care is assigned to a particular speciality. The medical and surgical specialities included in this study are listed in Table 3.1 along with their code identifiers. All other episodes were excluded from further analysis. The datasets were further reduced to include only acute care NHS Trusts. This excluded episodes of care within other institutions such as hospices and long term psychiatric facilities which were not relevant to this study. Codes for the NHS Trusts included for analysis are listed in Appendix 7.2.

Please note: In 2007/08 Charing Cross and Hammersmith NHS Trust merged with St Mary's NHS Trust to form Imperial College Healthcare NHS Trust. By using the Transform data>recode into same variables option in SPSS, data for the two original Trusts could be merged.

### *Deletions*

Each episode has a code identifying the method of admission. Any episodes with inappropriate admission codes e.g. '31 – admitted ante-partum' were excluded. The remaining admission methods are listed in Table 3.2 and were further assigned as 'Emergency' and 'Elective'. Episodes with blank ages, age younger than 16 and invalid ages (4-digit) were deleted.

**Table 3.1 Speciality codes included in analysis**

| Code | Name | Status |
|---|---|---|
| 300 | General medicine | Medical |
| 301 | Gastroenterology | Medical |
| 302 | Endocrinology | Medical |
| 303 | Clinical haematology | Medical |
| 305 | Clinical pharmacology | Medical |
| 313 | Clinical immunology and allergy | Medical |
| 314 | Rehabilitation | Medical |
| 315 | Palliative medicine | Medical |
| 320 | Cardiology | Medical |
| 330 | Dermatology | Medical |
| 340 | Respiratory medicine (also known as thoracic medicine) | Medical |
| 350 | Infectious diseases | Medical |
| 352 | Tropical medicine | Medical |
| 360 | Genitourinary medicine | Medical |
| 361 | Nephrology | Medical |
| 370 | Medical oncology | Medical |
| 400 | Neurology | Medical |
| 410 | Rheumatology | Medical |
| 430 | Geriatric medicine | Medical |
| 823 | Haematology | Medical |
| 100 | General surgery | Surgical |
| 101 | Urology | Surgical |
| 110 | Trauma & orthopaedics | Surgical |
| 120 | ENT | Surgical |
| 130 | Ophthalmology | Surgical |
| 140 | Oral surgery | Surgical |
| 145 | Oral & maxillo-facial surgery | Surgical |
| 150 | Neurosurgery | Surgical |
| 160 | Plastic surgery | Surgical |
| 170 | Cardiothoracic surgery | Surgical |
| 180 | Accident & emergency | Surgical |
| 190 | Anaesthetics | Surgical |
| 192 | Critical care medicine | Surgical |

**Table 3.2 Admission methods and codes included in study**

| Admission method code | Admission description |
|---|---|
| **11** | Elective waiting list |
| **12** | Elective booked |
| **13** | Elective planned |
| **21** | Emergency via AED |
| **22** | Emergency via GP |
| **23** | Emergency via bed bureau |
| **24** | Emergency via outpatient clinic |
| **28** | Emergency other |
| **81** | Transfer of patient from other hospital not emergency |

## Linking ONS Death Data

Linkages were created between HES data and death registry information (Office of National Statistics; ONS) to establish alive-dead status and date of death for all patients. The register is the national record of death from any cause whether in or out of hospital and information was available for deaths registered more than 30-days beyond the end of each data year included in this study. Linkage was done using the unique HES number (HESID) identifying each individual patient.

We were provided with death registry data from the Office of National Statistics in SPSS format files. We were then able to merge the death dates into our Master files. This was achieved by first sorting both the ONS file and our Master Datasets by HESID. Then, the death dates are merged from the ONS file onto our Master file using the SPSS functions 'Merge data' and 'Adding variables'.

A new HESID system was introduced for the 2007/08 data year. To capture all deaths we had to match an individual's old HESID with their new HESID code. A key

based on the unique identifier for each episode (EPIKEY) was provided by Northgate Information Solutions[139] which allowed the new HESID to be assigned to patients having episodes of care in 2006/07 which matched their HESID in 2007/08 dataset allowing the two sets of data to be merged.

We were provided with all death dates for 2006 to over 30 days beyond the end of the 2007/08 data.

### The ERCP Datasets

We then extracted the ERCP episodes to create our ERCP datasets. In 2006/07 data from the following Trusts, RAX and RK5, were not included as they had HES data for fewer than 10 ERCP procedures.

The final ERCP datasets contain a row of data for each whole ERCP procedure performed on an individual within the two data years. If a patient had two ERCPs on different dates (even if in the same episode) this would be counted as two ERCPs and appears as two rows in the dataset, but a patient who has two ERCP codes on the same date should be counted as only one ERCP procedure and therefore have only one entry for this procedure. The date on which a procedure is performed is contained within the HES dataset under a date variable.

There are 42 OPCS codes pertaining to ERCP in HES (See Table 3.3). Hence, there is variability in the precise combination of codes used to describe any one procedure. Additional Y and Z codes are also used to identify the types of biopsy taken. Thus, one ERCP procedure may have more than one procedure code assigned to it and

there can be many different code combinations, all indicating that an ERCP has been performed, within the datasets.

**Table 3.3 ERCP OPCS procedure codes**

| Procedure code | Procedure description |
|---|---|
| J381 | Endoscopic incision of sphincter of Oddi, Endoscopic sphincterotomy of sphincter of Oddi and removal of calculus |
| J382 | Endoscopic incision of sphincter of Oddi, Endoscopic sphincterotomy of sphincter of Oddi and insertion of tubal prosthesis into bile |
| J388 | Endoscopic incision of sphincter of Oddi, Other specified |
| J389 | Endoscopic incision of sphincter of Oddi, Unspecified |
| J391 | Other therapeutic endoscopic operations on ampulla of vater, Endoscopic sphincterotomy of accessory ampulla of vater |
| J398 | Other therapeutic endoscopic operations on ampulla of vater, Other specified |
| J399 | Other therapeutic endoscopic operations on ampulla of vater, Unspecified |
| J401 | Endoscopic retrograde placement of prosthesis in bile duct, Endoscopic retrograde insertion of tubal prosthesis into both hepatic ducts |
| J402 | Endoscopic retrograde placement of prosthesis in bile duct, Endoscopic retrograde insertion of tubal prosthesis into bile duct nec |
| J403 | Endoscopic retrograde placement of prosthesis in bile duct, Endoscopic retrograde renewal of tubal prosthesis in bile duct |
| J404 | Endoscopic retrograde placement of prosthesis in bile duct, Endoscopic retrograde removal of tubal prosthesis from bile duct |
| J405 | Endoscopic retrograde insertion of expanding covered metal stent into bile duct |
| J406 | Endoscopic retrograde insertion of expanding metal stent into bile duct NEC |
| J407 | Endoscopic retrograde renewal of expanding metal stent in bile duct |
| J408 | Endoscopic retrograde placement of prosthesis in bile duct, Other specified |
| J409 | Endoscopic retrograde placement of prosthesis in bile duct, Unspecified |
| J411 | Other therapeutic endoscopic retrograde operations on bile duct, Endoscopic retrograde extraction of calculus from bile duct |
| J412 | Other therapeutic endoscopic retrograde operations on bile duct, Endoscopic dilation of bile duct nec |
| J413 | Endoscopic retrograde lithotripsy of calculus of bile duct |
| J414 | Endoscopic retrograde photodynamic laser therapy of lesion of bile duct |
| J418 | Other therapeutic endoscopic retrograde operations on bile duct, Other specified |
| J419 | Other therapeutic endoscopic retrograde operations on bile duct, Unspecified |
| J421 | Therapeutic endoscopic retrograde operations on pancreatic duct, Endoscopic retrograde insertion of tubal prosthesis into pancreatic duct |
| J422 | Therapeutic endoscopic retrograde operations on pancreatic duct, Endoscopic retrograde renewal of tubal prosthesis in pancreatic duct |
| J423 | Therapeutic endoscopic retrograde operations on pancreatic duct, Endoscopic retrograde removal of calculus from pancreatic duct |

| | |
|---|---|
| J424 | Therapeutic endoscopic retrograde operations on pancreatic duct, Endoscopic retrograde drainage of lesion of pancreas |
| J425 | Therapeutic endoscopic retrograde operations on pancreatic duct, Endoscopic retrograde dilation of pancreatic duct |
| J428 | Therapeutic endoscopic retrograde operations on pancreatic duct, Other specified |
| J429 | Therapeutic endoscopic retrograde operations on pancreatic duct, Unspecified |
| J431 | Diagnostic endoscopic retrograde examination of bile duct and pancreatic duct, Endoscopic retrograde cholangiopancreatography and biopsy of lesion of ampulla of Vater |
| J432 | Diagnostic endoscopic retrograde examination of bile duct and pancreatic duct, Endoscopic retrograde cholangiopancreatography and biopsy of lesion of biliary or pancreatic |
| J433 | Endoscopic retrograde cholangiopancreatography and collection of bile |
| J438 | Diagnostic endoscopic retrograde examination of bile duct and pancreatic duct, Other specified |
| J439 | Diagnostic endoscopic retrograde examination of bile duct and pancreatic duct, Unspecified |
| J441 | Diagnostic endoscopic retrograde examination of bile duct, Endoscopic retrograde cholangiography and biopsy of lesion of bile duct |
| J448 | Diagnostic endoscopic retrograde examination of bile duct, Other specified |
| J449 | Diagnostic endoscopic retrograde examination of bile duct, Unspecified |
| J451 | Diagnostic endoscopic retrograde examination of pancreatic duct, Endoscopic retrograde pancreatography and biopsy of lesion of pancreas |
| J452 | Diagnostic endoscopic retrograde examination of pancreatic duct, Endoscopic retrograde pancreatography and collection of pancreatic juice |
| J453 | Diagnostic endoscopic retrograde examination of pancreatic duct, Endoscopic retrograde pancreatography through accessory ampulla of vater |
| J458 | Diagnostic endoscopic retrograde examination of pancreatic duct, Other specified |
| J459 | Diagnostic endoscopic retrograde examination of pancreatic duct, Unspecified |

To identify all episodes containing ERCP procedures we searched for all 42 codes within each procedure position. The specific syntax used to do this within SPSS can be found in Appendix 7.1. We first extracted a new dataset containing all episodes of care with an ERCP code in the 'PROCEDURE 1' variable. Within this new dataset we created a new variable 'ERCPDATE' which was updated to equal the date Procedure 1 was performed. Then a variable 'ERCPPOSITION' was created and updated to show a '1' to indicate the Procedure 1 position. This process was then repeated for procedure positions 1-14, each time creating a new separate dataset. In each separate dataset the new variables, ERCPDATE and ERCPPOSITION, were created and updated to show the date and position for the procedure extracted i.e. When ERCP codes were searched for in 'PROCEDURE 4' the new dataset extracted would be updated with the two new variables; ERCPDATE showing the date for the procedure in position 4, and the variable ERCPPOSITION which would equal '4' to indicate ERCP procedure code in position 4. The resulting seven datasets should have identical variable headings in the same order so that they can then be merged. This process was repeated for both data years.

### *Identifying Duplicates*

Duplicate entries were then identified and deleted. This leaves a single entry for each ERCP procedure. This involved sorting the datasets by HESID, ERCPDATE and ERCPPOSITION. Duplicates were identified based on the HESID and ERCPDATE variables using the 'identify duplicates' function in SPSS. Duplicate entries (rows of data with identical ERCP code dates) were then deleted, leaving one row of data for each unique ERCP episode that contains all the episode information. If a patient had

two ERCPs on two different dates within an episode of care, then they will have a separate entry for each procedure i.e. two rows of data.

### *Deletions*

Records with missing or invalid procedure dates were then deleted. Episodes with inconsistent dates for procedures, admission, discharge or death were deleted. Episodes with invalid or blank ages, age under-16 years old or 4-digit ages were deleted. Those Trusts not included in our study had all their episodes deleted. Episodes with an admission method not to be included in the study were erased (e.g. maternity codes).

## Additional Variables

In addition to the new variables created during the process of dataset extraction (see above), further variables had to be derived to assist data analysis. The following section describes each additional variable and the methods used to create them, with reference to specific SPSS syntax in Appendix 7.1.

The HES data set contains a unique code for each patient allowing them to be identified across all data years. It is generated using their NHS number, local patient identifier, provider code, patient's postcode, sex and date of birth. This variable is called HESID or EXTRACT_HESID in data extracts requested by customers. As the method of generating the unique code changed between our datasets we renamed our HESID variables as follows:

'OLDHESID': This is a six digit unique identifier for each individual patient. This was present in the original 2006 – 2007 dataset provided by Northgate

'NEWHESID': The method of assigning unique identifiers for patients changed between 2007 and 2008. The dataset for 2007 – 2008 was provided with the new 13 digit identifiers. Some patients had episodes of care in both years so Northgate provided a look-up file containing the EPIKEY of the episodes in 2006 – 2007 attached to the patients new 13 digit HESID from 2007 – 2008. The NEWHESID variable was then added to the 2006 – 2007 dataset by merging the two files. This was done by sorting the 2006 – 07 data file and the look-up file into the same order with the same variable names. The 'Data' tool in SPSS was then used to 'Merge Files' by 'Adding variables' and 'Matching cases' on key fields in sorted files. This would add the 'NEWHESID' variable to the 2006 – 2007 dataset.

The additional variables we derived are described here:

**'DATAYEAR'**: This is simply a marker to indicate which year the ERCP procedure took place. If the ERCP procedure in this row of data occurred between April 1st 2006 and March 31st 2007 then the DATAYEAR marker would show 200607. Likewise if the procedure took place between April 1st 2007 and March 31st 2008 the marker would show 200708. Once the two datasets were merged this marker would allow the two years to be easily identified.

**'FIRSTERCP'**: In this column a '1' indicates that the ERCP procedure in this row of data was the first to occur for that individual in that data year. A '0' indicates that it was not the first ERCP procedure in that data year but a subsequent one. A '0' does not indicate the last ERCP procedure in the data year. The 'FIRSTERCP' variable was derived from HESID and ERCPDATE. The dataset was first sorted in ascending order by HESID and ERCPDATE. Using the 'Identify duplicates' function in SPSS all ERCP

procedures for each HESID / individual were identified, with a marker '1' indicating the first occurrence by date.

**'LASTERCP'**: In this column a '1' indicates that the ERCP procedure in this row of data is the last to occur for that individual in that data year. A '0' indicates that the procedure was not that last but a previous procedure. Again 'LASTERCP' was derived using HESID, ERCPDATE and the 'Identify Duplicates' function in SPSS. The data set was sorted by HESID and ERCPDATE in ascending order but this time the identify duplicates function was used to mark the last occurring procedure as '1' ('PrimaryLast').

**'DEATHDATE'**: This shows the date of death for a patient. Hospital Episode Statistics data does not include information on patient deaths. The Office of National Statistics provided a file containing dates of all deaths from April 2006 through April 2008. The dates were attached to HESID so we were able to merge this file with our Northgate files to create the DEATHDATE variable. All deaths had to be merged with both data year files as some patients who had a procedure in 2006 – 2007 will have died in 2007 – 2008. The date of death for a patient was attached to all their episodes of care, not just their last episode.

**'DODMINUSERCPDATE'**: This variable was derived from ERCPDATE and DEATHDATE using the 'Date and time wizard' tool in SPSS. The date of the ERCP procedure was subtracted from the date of death to give a number of days between the two events.

**'AGEGROUP'**: Age was divided up into ten year age groups labelled as 1 to 5. This variable shows which of the five age groups an individual belongs to for that particular episode. The syntax to derive this variable is in Appendix 7.1

**'AGEBAND'**: This variable indicates which five year age band an individual belongs to in that episode. See Appendix 7.1

**'SPECIALITYTYPE'**: A '1' indicates a surgical speciality and a '2' indicates a medical speciality. The syntax to generate this variable can be found in Appendix 7.1.

**'ADMIMETHTYPE'**: This variable was added to identify if an episode of care occurred during an emergency admission or non-emergency admission. Each episode was assigned to one of four groups, labelled 1 to 4. Group 1 includes 'Elective ordinary' admissions, Group 2 are 'Elective day case' admissions, Group 3 'Elective regular attendance' admissions and Group 4 are 'Emergency' admissions. These variables were derived from 'Admission Method' and 'Patient Classification'[140]. Appendix 7.1 shows the syntax.

**'DEATH7'**: A '1' indicates the individual died within seven days of their ERCP procedure. This is derived from 'DODMINUSERCPDATE', where if that variable is equal to or less than 7, DEATH7 equals 1. Otherwise DEATH7 equals zero. DEATH7 equal to zero means the individual died more than seven days after their ERCP procedure or, they are still alive.

**'DEATH30'**: This variable was derived in a similar way to DEATH7 but a '1' indicates the individual died within 30 days of their ERCP procedure. The 'DEATH30' group will include all those who are also 'DEATH7'.

**'DIEDCATEGORY'**: Individuals are categorised into 4 groups. '0' equals 'ALIVE', '1' equals died within seven days of ERCP, '2' =equals died between 8 and 30 days of ERCP and '3' equals died 31 days or more after ERCP.

**'DIEDINHOSPITAL'**: This variable where a '1' indicates the patient died in hospital is derived from the 'DISMETH' variable.

**'YZCODES'**: This variable simply indicates if there are 'Y' or 'Z' procedure codes present in this episode of care. The syntax and code details are in Appendix 7.1.

**'DEATHMARKERALL'**: A one indicates the patient has died since their ERCP.

**'NOOFERCPOCCASSIONSINTHISDATAYR'**: This provides the number of ERCP occasions each patient has had in the data year. For example, if in one episode a patient has two ERCPs on different dates, the number for this patient will be 2.

**'NOOFERCPPROCSONTHISOCCASSION'**: This is the number of ERCP procedures performed at the ERCP occasion, for a full list of ERCP codes see Table 3.3.

**'NOOFADMISSIONSINYEARFORTHISPATIENT'**: This indicates the total number of admissions this patient has had in this data year. It includes all admissions, not just those containing ERCP procedures.

**'TOTALNOOFALLPROCSONTHISDATE'**: This variable indicates the total number of procedure codes for this ERCP date. It includes non-ERCP codes as well as ERCP codes.

**'CO-MORBIDITY1 – 14'**: A binary variable was used to identify the presence or absence of one of the diagnoses listed in the Charlson co-morbidity index[141-143] in

each of the diagnostic fields (DIAG01 – 14). This entailed creating fourteen new datasets which were then merged with the original to give variables for each position (See Appendix 7.1 for syntax and Appendix 7.3 for the list of diagnoses contained within our modified Charlson Index). Coding practice is known to vary across institutions in terms of precision and depth[25;26]. Hence we took the decision to look for diagnoses in all diagnostic fields and not just the first position. *(A description of the Charlson Co-morbidity index can be found at the end of this chapter.)*

**'SUMCOMORB'**: Using the 'Transform' tool within SPSS the total number of co-morbid diagnoses for a given episode was calculated. For example, if codes in DIAG01 and DIAG05 referred to diagnoses in the Charlson co-morbidity index then CO-MORBIDITY1 and CO-MORBIDITY5 would both contain a '1', the other CO-MORBIDITY fields would contain a '0'. The SUMCOMORB variable for this episode of care would therefore equal two.

**'CO-MORBIDITY'**: This was a binary variable to show the presence or absence of any co-morbidity, as per the Charlson Index, for each episode of care. The above example would therefore have a '1' in this field. This was calculated using the 'Transform' tool such that if SUMCOMORB > 0 then CO-MORBIDITY = 1. This marker includes patients with cancer. It was decided to create a further variable for co-morbidity that excluded cancer to avoid distorting results – see below at non-cancer co-morbidity.

**'CANCER1 – 14'; 'SUMCANCER'; 'CANCER'**: Using the list of cancer diagnoses in Appendix 7.1 instead of the co-morbidity codes the process outlined above for

marking the presence of co-morbidity was repeated to produce variables marking the presence of a cancer diagnosis.

The process was repeated using different lists of diagnostic codes (all contained within **Appendix 7.1**) to create the following variables:

**'HPBCA1 – 14'; 'SUMHPBCA'; 'HPBCA'**: For hepato-pancreatobiliary cancer

**'PANC1 – 14'; 'SUMPANC'; 'ACUTEPANCREATITIS'**: For acute pancreatitis

**'GS1 – 14'; 'SUMGS'; 'GALLSTONES'**: For gallstones

**'NONCANCERCOMORB1–14', 'SUMNONCANCERCO-MORBIDITY' and 'NONCANCERCO-MORBIDITY'**:

The variables marking the presence of codes for non-cancer co-morbidity were used for further analysis of co-morbidity effect, rather than the original 'CO-MORBIDITY' marker as it was recognised that cancer was often an indication for ERCP and therefore using the original 'CO-MORBIDITY' marker we would be double counting patients and distorting results.

**'NONHPBCANCER'**: This variable marks the presence of cancers that do not affect the liver, pancreas or biliary tree. For example patients with a diagnostic code for lung cancer or gastric cancer will have a '1' in this field.

**'BSGPARTICIPANT'**: This variable is derived from the admitting Trust for this episode (PROCODE). A '1' indicates that the Trust contributed to the audit carried out by the British Society of Gastroenterology in 2006[129;133]. Syntax for this variable

is held in Appendix 7.1 and the list of participating Trusts in Appendix 7.5 Table A3.1.

**'BSGTOTAL'**: The number in this field indicates the number of ERCP cases the admitting Trust contributed to the BSG audit (see above).

### Final ERCP dataset

The original analysis was performed on a dataset containing only the *last* ERCP procedures performed on a patient within the designated time frame (April 1st 2006 to March 31st 2007). At that point we only had data for the year 2006/07 and so to allow 30-day follow-up we looked just at the first 11 months of the data year i.e. April 1st 2006 to February 28th 2007. Results from this work were disseminated to all doctors performing ERCP in England along with a feedback questionnaire (see 'Engagement with Clinicians' section below) and also presented in abstract form at the British Society of Gastroenterology conference[144]. A major source of comment and feedback was concern over the use of 'last ERCP' rather than first. Other studies looking at ERCP outcomes have looked at 'first ERCP'[129] on the basis that the analysis is more robust with fewer confounding factors affecting outcomes – the data are 'cleaner'. So, following this feedback the original methodology was refined and subsequent analysis was performed on first ERCP procedures only. This entailed identifying procedures in the last nine months of each data year and extracting these episodes into a new dataset for further analysis. Avoiding procedures in the first three months of each year minimised contamination from previous years.

## Data quality issues

Initial analysis was done with only the data for 2006/07 available. When it came to merging this dataset with the one subsequently developed from the 2007/08 data a number of issues arose which meant we had to go back to the original 2006/07 data and repeat the data extraction and creation of our 2006/07 dataset before re-merging our two years of data to create the final dataset.

When we first merged the two datasets it became apparent that there were duplicates within the 'FIRST ERCP' variable i.e. for an individual HESID more than one ERCP entry was designated as the first. We went back to the '0607 all occasions' dataset and re-calculated 'FIRSTERCP'. For most entries the duplicate and primary status was unchanged for first ERCP but in a few instances where originally a 'FIRSTERCP' procedure has been designated as a primary, on re-calculation they were now duplicates. The reverse was also seen to occur. Further investigation uncovered the source of error: The original procedure for identifying duplicates was based on sorting procedures according to HESID, ADMDATE and ERCPDATE. At that time it had not been noted that some patients had ERCPDATE that was before ADMDATE and thus when running the 'identify duplicates' function in SPSS the dataset was incorrectly sorted. Having identified the problem, episodes with incompatible dates were deleted and the analyses run again sorting cases by HESID and ERCPDATE only.

## Validation of results

Hospital Episode Statistics data have been used to analyse mortality following several procedures and diseases[145-155] but have not previously been used to look

specifically at ERCP outcomes in the UK. Linkage to death registration status should improve capture of mortality by including deaths outside of hospital. We wished to validate the robustness of the data for ERCP procedures by undertaking a series of checks.

First, we compared the demographic and basic clinical diagnoses of ERCP cases identified from HES data with the characteristics of the patient population reported in a previous survey of ERCP practice in England which used a clinically detailed prospective dataset[129].

Second, in our own hospital, we were able to compare our own records for 30-day post-ERCP deaths with the anonymous national data and infer from age, gender, diagnosis and procedure date if there was or was not consistency.

Third, our engagement with front-line teams sought feedback from all hospitals on the overall approach to analysis and the data coded and submitted by their local institution. This also involved a steering group of representatives from the British Society of Gastroenterology, NHS information centre, medical and surgical gastroenterologists and public health experts.

## Engagement with Clinicians

A key component of the study was the sharing of preliminary data outputs with front-line clinicians, seeking advice on refinements to the analytical approach, views on coding quality and interpretation and usefulness or otherwise of the analyses. There is no 'official' list of Gastroenterologists or of those who perform ERCP. By combining listings held by the specialist society (British Society of Gastroenterology;

BSG) and NHS staff records we constructed an e-mail list of gastroenterologists that covered all acute Trusts in England. Through direct contact with Trusts we were also able to identify, contact and include other clinicians including surgeons and radiologists who perform ERCP. Pilot analyses of institutional-level comparative data were sent out electronically to each clinician along with a questionnaire and the data presented at a national conference.[144] Feedback was used to inform the final analytical approach and to assess the validity of our initial findings.

The following questions were asked:

1. **Does the pilot data for your Trust accurately reflect the volume of ERCP procedures performed annually?** This was asked to assess the accuracy and validity of our basic findings.
2. **Are ERCPs performed on more than one hospital site within your Trust?** We wanted to make this exercise as fruitful as possible and therefore included some additional data gathering questions. This was also an attempt to gather information about service structure and how that might vary.
3. **Does your unit accept transfer of patients for ERCP from other local Trusts?** Again this was an attempt to get more information about service structure that was not available from HES data. This was specifically trying to look for differences in workload that might explain differences in outcome cross Trusts
4. **Does your unit perform day case ERCP (discharge home the same day)?** Does service structure account for any variability in outcomes between Trusts?
5. **Does your Trust undertake ERCP in critically-ill patients requiring intensive care and/or ventilation?** This question is looking for variation in practice and workload.

6. **Are you aware of local coding or administrative factors that might result in incomplete recording of ERCP procedures?** We had already found results that made some units outliers in ERCP outcomes and wished to confirm that a significant cause for this was simply data retrieval and accuracy rather than poor practice.
7. **Does your unit perform in-house audit for all-cause mortality within 30-days of ERCP?** Answers given here would obviously validate answers given to earlier questions but also contribute to the potential need for our project.
8. **Does the pilot crude mortality figure generated for your Trust appear accurate?** A straightforward request that would highlight any discrepancies with our own findings.

The questionnaire was sent out in Excel format with space for free text comment available for several of the questions. Responses are summarized and discussed in the results section of this chapter.

### Statistical analysis

The Hospital episode data were stored, manipulated and analysed using the SPSS statistical package (SPSS Inc., Chicago, USA). National-level analyses of factors associated with all-cause death were identified by univariate analysis and binary logistic regression models. Funnel plots of institutional-level data were generated using analytical tools provided by the Association of Public Health Observatories.[156]

## The Charlson Index of co-morbidity

Patient outcomes following a particular surgical event or disease occurrence can be affected by the presence of other disease states. Co-morbidity has been defined by Feistein[157] as ''any distinct additional entity that has existed or may occur during the clinical course of a patient who has the index disease under study''. These co-morbid conditions can act as confounders to the particular event being studied leading to loss of internal validity or bias within studies. The co-morbidity may also act as an effect modifier and therefore cause inaccurate results or loss of external validity. Therefore it is desirable to correct or adjust for these effects when conducting outcome studies. Identifying the presence and nature of co-morbid conditions will therefore also allow predictions to be made about patient outcomes such as mortality.

The Charlson Index was developed in the 1980s as a means to estimate or predict risk of death from assessment of co-morbid conditions, for use in longitudinal studies.[142] Other scoring systems also exist that attempt to predict risk for outcomes such as death, length of stay and resource use. For example, the APACHE scoring systems for use in critically ill patients, the Kaplan & Feinstein model for classifying diabetic patients and the Elixhauser score. However, it is the Charlson Index and its modifications that have been used most widely in the literature.

The Charlson Index was developed empirically from the 1 year mortality data of a cohort of 604 patients admitted to New York Hospital with a wide variety of primary diagnoses. It was validated in a second cohort of 685 patients, treated for primary breast cancer at Yale New Haven Hospital, over 10 years. The resulting index

provides weighted scores (1, 2, 3 or 6) for 19 predefined co-morbid conditions. The total of these scores gives a measure of the burden of co-morbid disease for an individual, from which predictions about mortality risk can be made. Outcomes from population studies and trials can then be adjusted according to co-morbid burden to improve the generalizability of results.

The Charlson Index has been validated and used widely. Several adaptations including the Deyo and Dartmouth-Manitoba adaptations have been developed to enable it to be used with administrative databases and the International Classification of Disease (ICD) coding system. Here specific ICD-9 codes are selected to represent the individual co-morbid conditions stated in the original Charlson Index. Compared to direct case note review Charlson scores for individual co-morbid conditions derived from administrative databases may be less accurate but the overall mortality prediction is similar whether the score is derived from case notes or administrative datasets. Similarly, the differences between adaptations such as the two adaptations mentioned above are 'modest'. Depending on the aims of a study one adaptation may have slight advantage over another due to the inclusion or omission of codes describing procedures specific to certain conditions e.g. peripheral arterial bypass surgery for peripheral vascular disease, or renal dialysis. [19] For this reason it has been suggested by Romano et al and Ghali et al that the weighting of conditions in the Charlson Index can be derived from the population being studied by multivariate analysis and 'tailored' to the outcome being studied.

The advantages in time, cost and overall feasibility of using administrative databases with the Charlson Index over other methods of outcomes research may outweigh the disadvantages of a slightly less robust risk adjustment [19;37;143;158-178]. There are only a few studies that describe in detail how they adapt the Charlson Index for use in such studies[159;179;180;180]. We based our coding classification of co-morbid conditions on that used by the Dr Foster group.[177;181] For the ERCP data analysis we decided not to assign weighted scores to co-morbidity codes. Instead we indicated for each episode of care whether one of our selected co-morbidity codes was present or not (See Appendix 7.1 for the syntax used to identify co-morbid diagnostic codes and Appendix 7.3 for a list of the codes included). Further variables were included to indicate the number of co-morbid codes present for an episode of care and binary indicators were added for specific conditions. The number of co-morbid conditions was not used in the final analysis. The method of providing an ordinal index for co-morbidity has been used previously to look at post surgical outcomes[45].

Comparisons of the different methods of measuring co-morbid burden are numerous[161]. The Elixhauser method was published in the late 1990s and intended specifically for use with large, administrative inpatient datasets.[182] It was constructed to predict, specifically; hospital charges, length of stay and in-hospital mortality. By using DRG (Diagnostic resource groups) assignment it attempted to separate codes relating to the primary diagnosis from those relating to the secondary diagnoses. Only the secondary diagnoses were evaluated for co-morbid burden. Codes suggesting complications of medical care and procedures were

excluded as were several conditions that previous studies have shown to have low impact on mortality and other outcomes when not cited as a primary diagnosis. These exclusions included acute diagnoses such as pneumonia, urinary tract infection and respiratory failure as potential complications of treatment and conditions such as benign prostatic hypertrophy and diverticulosis as unimportant. Secondary diagnoses such as dementia, renal disease, cerebrovascular disease and inflammatory bowel disease were also excluded as co-morbid conditions as these were found to be statistically unrelated to length of stay, total charges or in-hospital mortality following univariate and multivariate analysis of the population used in the Elixhauser study. The Elixhauser group definitions of co-morbid conditions and complications are conservative which may explain why their correlation with mortality was weaker than that in other studies. Other potential limitations of this model are its exclusion of any patients discharged to another hospital or long-term care facility and its use of 'in-patient mortality' rather than all deaths.

The Acute Physiology and Chronic Health Evaluation (APACHE) score is a more clinically rich system of assessing short term risk of death in the critically ill patient. It utilises real-time measures of patient physiological status and is therefore difficult to apply in retrospect. Scores are determined within the first 24 hours of admission to a critical care unit and only re-calculated if a patient is re-admitted to critical care after discharge to ward or home. It has been extensively utilised in critical care literature with some treatment protocols dependent on a patient's APACHE score. It is not validated in non-critically ill patients, which along with the cost and time burdens of using this score, limits its use in population-based studies. Counter to

that though is that the Charlson Index has compared well to the APACHE II score in some critically ill patient groups, for example, acute myocardial infarction, although the APACHE II is better at predicting in-hospital mortality.[37;159]

The Charlson Index does have limitations. The co-morbid conditions it describes are based on those found within a relatively small sample size. The weightings used for the different diagnoses may not be appropriate for all patient groups, e.g. surgical patients. The impact of a particular disease on outcome may also change over time with the development of new therapies.

Clearly, the validity of the Charlson Index and many of the risk assessment tools will be dependent on the accuracy of clinical coding. There is strict guidance on coding which clerks must follow but misinterpretation can occur. The design of the HES database means that it is not always possible to accurately assign significance to a particular code. The code in the first position is presumed to be the main condition requiring admission to hospital with subsequent positions representing co-morbid conditions. But it is not possible to indicate within that episode of care, which conditions are 'active', pre-existing, new or old. Diagnoses can be assigned as co-morbid or secondary conditions when in fact they are iatrogenic complications. Codes for now inactive conditions may be carried forward from previous episodes. The chronology of diagnoses is difficult to ascertain as dates of use and origin are not attached to diagnostic codes as they are with procedure codes. Attaching dates to the codes has been shown to improve accuracy of such scores.[183] Coding bias, whereby the more severe the patient's primary condition the less likely their more 'mundane' diagnoses would be coded has been highlighted in previous

studies.[182]This will obviously affect measures of co-morbid burden. The accuracy of administrative data should increase as more of the code positions are used. Previously there were only 7 positions within HES available to provide secondary diagnostic codes, now there are 14. This change occurred between our two data years and as well as the average number of codes being given increasing; the proportion of the positions used increased. This, at least partially, may reflect changes in coding practice related to hospital funding.

## Results

The Master files extracted from the raw HES data provided by Northgate contained 10,753,151 episodes of care for 2006/07 and 11,296,023 episodes for 2007/08.

From these datasets 58,955 episodes of care containing an ERCP code were extracted for the financial year 2006/07 (60,786 episodes for 2007/08). Following deletions of duplicates and erroneous data we retrieved 37,386 unique ERCP procedure episodes for 2006/07 of which 410 (1.1%) were excluded owing to invalid data entries (e.g. default/nonsense dates or missing key data fields). ERCPs were coded by 149 acute NHS Trusts in England. Procedure numbers were similar for 2007/08 (38,108 unique ERCP procedures; 518 (1.4%) episodes deleted due to invalid or missing data).

### Last ERCP Analysis

Our initial analysis was performed using only the last performed ERCP procedures. Following feedback from front-line teams and the steering group we continued analysis on **first** ERCP procedures for individual patients. Results for the original

analysis on ‘last ercp’ were very similar to those on ‘first ercp’, with broadly similar conclusions. See Table 3.4.

**Table 3.4 Results for 'Last ERCP'. Patient characteristics and univariate analysis of factors associated with all-cause mortality after last ERCP procedure**

| Variable | 2006-2007 | *p* |
|---|---|---|
| **Total ERCPs** | 34,817 | |
| **Last occurring ERCP (First 11 months)** | 26,171 | |
| **Mean age in years (range, SD)** | 66 (16-105, 17) | |
| **Male Gender (n)** | 40.4% (10,585) | |
| **Emergency admission (n)** | 47.5% (12,418) | |
| **Cancer diagnosis (n)** | 17.4% (4,562) | |
| **Co-morbidity (n)** | 30.5% (7,974) | |
| **Mortality at 7 days (n)** | | |
| ***Overall*** | **1.6% (427 of 26,171)** | |
| *Emergency admission* | 2.7% (333 of 12,418) | ***p*<0.001** |
| *Non-emergency admission* | 0.7% (94 of 13,753) | |
| ***Cancer*** | **5.7% (259 of 4,562)** | ***p*<0.001** |
| ***Non-cancer*** | **0.7% (168 of 21,609)** | |
| *Age 85+* | 3.8% (121 of 3188) | ***p*<0.001** |
| *Age under 55 years* | 0.25% (15 of 5949) | |
| **Mortality at 30 days (n)** | | |
| ***Overall*** | **6.4% (1,670 of 26,171)** | |
| *Emergency admission* | 9.7% (1205 of 12,418) | ***p*<0.001** |
| *Non-emergency admission* | 3.4% (465 of 13,753) | |
| ***Cancer*** | **23.7% (1080 of 4562)** | ***p*<0.001** |
| ***Non-cancer*** | **2.7% (590 of 21,609)** | |
| *Age 85+* | 12.9% (410 of 3188) | ***p*<0.001** |
| *Age under 55 years* | 1.5% (88 of 5949) | |

## First ERCP Analysis

Within each data year a cohort of patients who underwent their first ERCP procedure between 1st July and 31st March were selected (Quarters 2-4). By excluding cases from the first quarter of the data year we were able to avoid including patients who may have undergone an earlier procedure within the preceding 3 months. This yielded a study population of 20,246 patients for 2006 to 2007 and 20,692 for 2007 to 2008.

The characteristics of patients at the time of first ERCP are summarised in Table 3.5. The cohorts from 2006/07 and 2007/08 were similar in terms of total numbers, demographics and clinical features.

Over half the patients were female (59.3% in 2006/07 and 58.9% in 2007/08). The mean age of patients was approximately 66 years old in both years (66.2 and 66.6 years) with the age range also being fairly consistent between the two data years (16 to 105 years old in 2006/07 and 16 to 108 years old in 2007/08). Just over half of all ERCP episodes took place within an emergency admission (53.1% and 52.0%).

The commonest coded diagnoses for first ERCP were gallstone-related (57.3% and 58% of patients in each year). Cancer diagnoses were coded in 14-15% of patients. This included 2% of patients having codes for both cancer and gallstones and nearly 13% of patients with codes for cancer alone with no codes for gallstones. Approximately one quarter of all patients were coded as having one or more non-cancer co-morbid conditions.

Across the two years, 711 individual ICD codes were utilised in the first diagnostic code position. 90% (36,928) of primary diagnoses were made with just 40 individual codes. The remaining 10% (4,010) consisted of 671 codes. Nearly half (45%) of the ICD codes used were only used only once over the two years.

**Table 3.5 Patient characteristics and crude all-cause mortality for first ERCP procedures performed in England during the second, third or fourth quarters of the 2006/07 and 2007/08 data years**

| | 2006/07 | 2007/08 |
|---|---|---|
| **Patients, *n*** | 20,246 | 20,692 |
| **Female gender, *n (%)*** | 12,001 (**59.3%**) | 12,194 (**58.9%**) |
| **Age, *mean (SD)*** | 66.2 (17) years<br>(Range: 16-105) | 66.6 (17) years<br>(Range: 16-108) |
| **Admission type, *n (%)*** | | |
| ***Elective*** | 9,476 (**46.9%**) | 9,935 (**48.0%**) |
| ***Non-elective (emergency)*** | 10,750 (**53.1%**) | 10,757 (**52.0%**) |
| **Diagnosis, *n (%)*** | | |
| ***Gallstones (no cancer)*** | 11,595 (**57.3%**) | 11,992 (**58.0%**) |
| ***Cancer (no gallstones)*** | 2,552 (**12.6%**) | 2,644 (**12.8%**) |
| ***Cancer and gallstones*** | 401 (**2.0%**) | 441 (**2.1%**) |
| ***Other diagnoses*** | 5,698 (**28.1%**) | 5,615 (**27.1%**) |
| **Any non-cancer co-morbidity, *n (%)*** | | |
| ***Absent*** | 15,717 (**77.6%**) | 15,678 (**75.8%**) |
| ***Present*** | 4,529 (**22.4%**) | 5,014 (**24.2%**) |
| **Died within 7 days of first-recorded ERCP, *n (%)*** | 253 (**1.3%**) | 286 (**1.4%**) |
| **Died within 30 days of first-recorded ERCP, *n (%)*** | 1,078 (**5.3%**) | 1,093 (**5.3%**) |

## All-cause mortality after first ERCP in England

All-cause mortality within seven days of first ERCP was below 1.5% and at 30 days was 5.3% (Table 3.5). Cases with a coded cancer diagnosis accounted for 57.2% of deaths within 30 days in 2006/07 and 61.2% in 2007/08. Cases with a coded hepato-pancreatobiliary cancer accounted for 43.2% of deaths within 30 days of first ERCP (Table 3.6). This is consistent with the role for ERCP in palliating biliary obstruction in incurable pancreatic or biliary malignancy. Of patients without a cancer diagnosis coded, all-cause mortality was 2.4% at 30-days in both years. The most common primary diagnosis in this group of patients was 'K83.1 Obstruction of bile duct' which was the ICD code in position one for 21% (n=95) of deaths in non-cancer patients. The next most common codes were 'K80.5 Calculus of bile duct without cholangitis or cholecystitis', 'K80.2 Calculus of gallbladder without cholecystitis' and 'K80.3 Calculus of bile duct with cholangitis'. Together, these three codes accounted for first diagnostic codes in a further 27% of deaths in non-cancer patients. The codes 'K80.2 Calculus of gallbladder without cholecystitis' and 'K83.1 Obstruction of bile duct' were the two commonest codes in second position and I10.X Essential (primary) hypertension the most common in the third position.

All these code frequencies were taken from the last episode before death (within 30 days of ERCP).

**Table 3.6 Diagnostic code frequencies for deaths within 30 days of ERCP in 2006/07**

| Diagnostic Group | n | % |
|---|---|---|
| Hepatobiliary or pancreatic malignancy | 466 | 43.2% |
| Other benign hepatobiliary or pancreatic conditions | 163 | 15.1% |
| Other malignancy | 150 | 13.9% |
| Gallstones | 97 | 9.0% |
| Other infections | 46 | 4.3% |
| Other gastrointestinal conditions (excluding infections) | 41 | 3.8% |
| Respiratory conditions (including infections) | 33 | 3.1% |
| Cardiovascular conditions | 29 | 2.7% |
| Renal conditions | 15 | 1.4% |
| Procedural complication codes | 13 | 1.2% |
| Others | 11 | 1.0% |
| Orthopaedic conditions | 7 | 0.6% |
| Neurological conditions | 7 | 0.6% |
| **Total** | **1078** | **100.0%** |

## Univariate and logistic regression analysis

Univariate analysis of the 2006/07 cohort showed that those dying within 30 days were older (mean age (sd): 76 years (12) versus 66 years (17) years; p<0.001), included more males (49.9% versus 40.2%; p<0.001), more patients treated during an emergency admission (74.1% versus 51.9%; p<0.001), more cases of cancer (58.5% versus 12.1%; p<0.001) and more patients with non-cancer co-morbidities (36.1% versus 21.6%; p<0.001) than patients still alive. Univariate analysis for 2007/08 was almost identical.

Binary logistic regression analysis of the 2006/07 data set confirmed age, sex, emergency admission, and cancer and non-cancer co-morbidity as independent predictors of 30-day death (Table 3.7). As would be expected, a cancer diagnosis was a strong predictor of 30-day death with an eight-fold increase in odds of death compared to non-cancer cases. Patients undergoing ERCP during an emergency admission had a two-fold increase in odds of death compared to electively scheduled cases.

The optimised model containing the five predictor variables was found to predict death with 75.6% sensitivity and 77.9% specificity when tested internally on the same dataset (i.e. the 2006/07 data). When re-tested against the 2007/08 dataset, performance was comparable with a sensitivity of 79.6% and specificity of 77.1%.

**Table 3.7 Factors associated with all-cause mortality within 30 days of first ERCP procedure. Binary logistic regression analysis of procedures performed in England during the second, third or fourth quarters of 2006/07 data year**

**(n=20,246 patients). Odds ratios with 95% confidence intervals**

| Independent variable | Odds ratio | 95% CI | *p* |
|---|---|---|---|
| **Age Group** | | | |
| **<55 years** | 1.00 | - | **-** |
| **55-64 years** | 2.196 | 1.593-3.028 | ***<0.001*** |
| **65-74 years** | 2.343 | 1.734-3.165 | ***<0.001*** |
| **75-84 years** | 3.788 | 2.842-5.048 | ***<0.001*** |
| **>84 years** | 6.163 | 4.578-8.296 | ***<0.001*** |
| **Sex** | | | |
| **Female** | 1.00 | - | **-** |
| **Male** | 1.220 | 1.068-1.394 | ***0.003*** |
| **Admission type** | | | |
| **Elective** | 1.00 | - | **-** |
| **Non-elective (emergency)** | 2.017 | 1.741-2.337 | ***<0.001*** |
| **Diagnosis** | | | |
| **Non-cancer** | 1.00 | - | **-** |
| **Cancer** | 8.611 | 7.539-9.836 | ***<0.001*** |
| **Non-cancer co-morbidity †** | | | |
| **Absent** | 1.00 | - | **-** |
| **Present** | 1.472 | 1.279-1.694 | ***<0.001*** |

Figures 3.1a&b show survival curves for patients with and without a cancer diagnosis, undergoing ERCP procedures. Given the strong influence of cancer diagnosis on risk of death at 30 days, we performed separate regression analyses for cases with cancer alone and non-cancer cases alone (Table 3.8). In non-cancer cases, the variables for increasing age-group, male gender, emergency admission

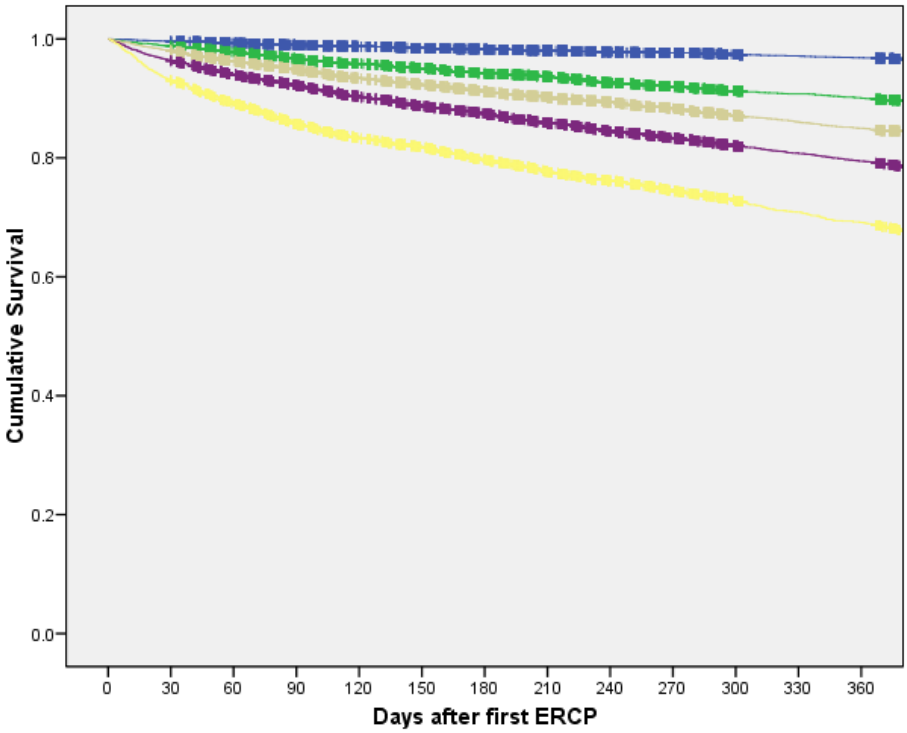
status and non-malignant co-morbidity retained their significant independent associations with death. However, among cancer cases alone only advanced age groups and emergency admission status were associated with significantly increased odds of all-cause death.

HES data contains a composite measure of socioeconomic deprivation, the Index of Multiple Deprivation, which allows patients to be ranked into quintiles ('fifths') according their area of residence (most deprived to least deprived). However, for patients undergoing their first ERCP, this variable did not demonstrate a significant association with 30-day mortality either on univariate analysis or when added to the binary regression models.

**Figures 3.1 a + b Survival curves**

**a. Benign diagnosis**

Age strata: <55 years old (blue line): 55-64; 65-74; 75-84; 85+ (yellow line)




**b. Cancer diagnosis.**

Age strata: <55 years old (blue line): 55-64; 65-74; 75-84; 85+ (yellow line)

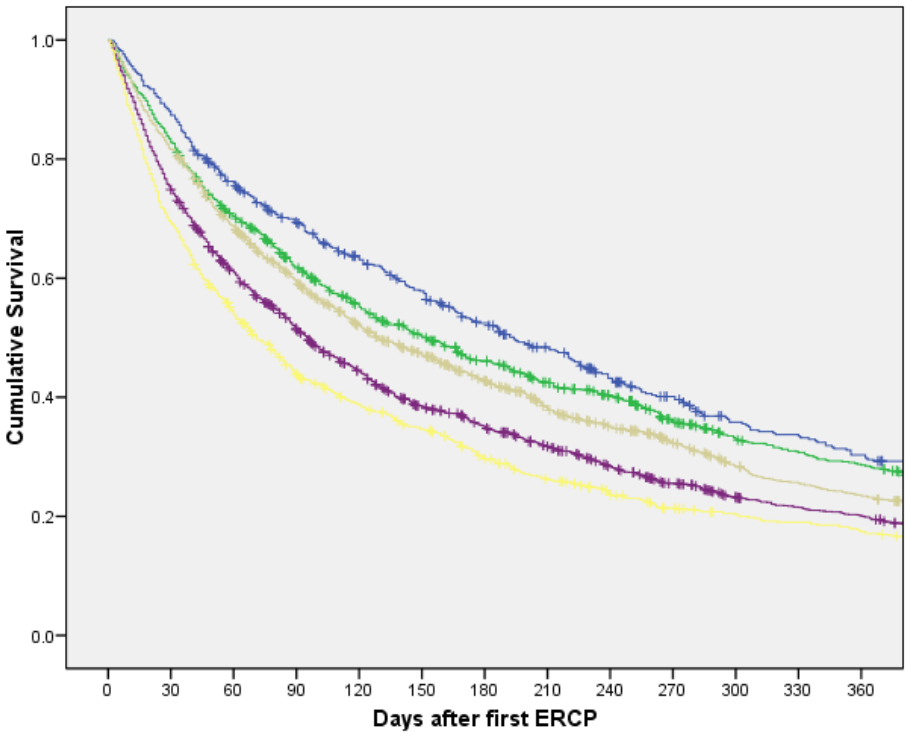


**Table 3.8 Factors associated with all-cause mortality within 30 days of first ERCP procedure. Binary logistic regression analysis of procedures performed in England during the second, third or fourth quarters of 2006/07 data year**

**(n=20,246 patients). Adjusted odds ratio with 95% confidence intervals. Reference case for each predictor is the first category (e.g. for age group, reference category is < 55 years of age)**

| Predictor variable | All patients (n=20,246) | | Benign diagnosis only (n=17,293) | | Cancer diagnosis (n=2,953) | |
|---|---|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| **Age Group** | | | | | | |
| **< 55 years** | 1 | - | 1 | - | 1 | - |
| **55-64 years** | **2.20*** | 1.59-3.03 | **2.67*** | 1.61-4.41 | 1.49 | 0.97-2.29 |
| **65-74 years** | **2.34*** | 1.73-3.17 | **3.49*** | 2.20-5.53 | 1.36 | 0.91-2.04 |
| **75-84 years** | **3.79*** | 2.84-5.05 | **5.69*** | 3.68-8.80 | **2.17*** | 1.46-3.22 |
| **>84 years** | **6.16*** | 4.58-8.30 | **10.76*** | 6.94-16.70 | **2.77*** | 1.82-4.21 |
| **Sex** | | | | | | |
| **Female** | 1 | - | 1 | - | 1 | - |
| **Male** | **1.22*** | 1.07-1.39 | **1.46*** | 1.20-1.77 | 1.01 | 0.84-1.21 |
| **Admission type** | | | | | | |
| **Elective** | 1 | - | 1 | - | 1 | - |
| **Non-elective (emergency)** | **2.02*** | 1.74-2.34 | **2.32*** | 1.85-2.89 | **1.76*** | 1.44-2.15 |
| **Non-cancer co-morbidity †** | | | | | | |
| **Absent** | 1 | - | 1 | - | 1 | - |
| **Present** | **1.47*** | 1.28-1.69 | **1.94*** | 1.59-2.36 | 1.12 | 0.92-1.37 |
| **Cancer diagnosis** | | | | | | |
| **Absent** | 1 | - | N/A | N/A | N/A | N/A |
| **Present** | **8.61*** | 7.54-9.84 | | | | |

†Presence of one or more Charlson co-morbidities (excluding cancer-related codes), ***$p$<0.05**

## A bedside tool for predicting mortality risk after ERCP

We pooled the data from 2006/07 and 2007/08 to yield a dataset containing 40,938 patients coded as having their first ERCP. These data were used to construct a 'look-up' table to provide an estimate of 30-day risk of death according to method of admission, underlying cancer diagnosis, presence of any major non-cancer co-morbid illness and age group (Table 3.9). A final diagnosis of cancer may not be firmly established at the time of ERCP but modern cross-sectional imaging and endoscopic ultrasound mean that malignancy is strongly suspected or known in most cases. This table could serve as a valuable resource in providing realistic expectations of prognosis at the time of selecting and consenting patients for ERCP.

The death rate among patients in the lowest risk category was just 0.4% (elective cases, under the age of 55 years, without co-morbidity and undergoing ERCP for a benign indication). We did not have access to cause of death and our linkage analysis of routinely coded data cannot distinguish reliably between deaths due to progression of underlying disease, additional interventions (e.g. surgical operations), unrelated chance events (e.g. traffic accidents), or procedural complications. However, a pooled estimate of procedural-related mortality for ERCP from 21 published surveys (16,855 patients in total) produced a figure of 0.33%.[118] The rate of procedure-related death in the previous English survey was 0.4%.[184]

At the other end of the mortality risk spectrum, mortality risk was almost 40% for the oldest patients (85 years and above) admitted as an emergency with underlying cancer and co-morbidity. Intervention in the highest-risk cases might be deemed

'futile' if only deaths are audited [185] but these data suggest that 60% of poorest-risk cases *survive* beyond 30 days. Mortality without intervention would likely be higher. ERCP has a key role in palliating malignant biliary obstruction and the 'look-up' table could support and inform more realistic, individualised discussions of risk and outcome between clinicians, patients and carers.

**Table 3.9 All-cause mortality within 30 days of first ERCP according to age group (y), admission method (elective or emergency), cancer diagnosis and presence of co-morbid conditions**
**Pooled data for quarters 2-4 of 2006/07 and 2007/08 for acute hospital Trusts in England (n=40,938 patients).**

| Emergency | Cancer | Co-morbidity | <55 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|
| **No** | **No** | **No** | 0.4% | 0.7% | 1.2% | 1.6% | 2.4% |
| **No** | **No** | **Yes** | 0.7% | 1.0% | 1.5% | 2.4% | 6.2% |
| **No** | **Yes** | **No** | 9.4% | 12.4% | 12.3% | 14.2% | 22.7% |
| **No** | **Yes** | **Yes** | 9.4% | 19.0% | 15.5% | 21.3% | 27.3% |
| **Yes** | **No** | **No** | 0.2% | 1.4% | 2.2% | 3.9% | 7.9% |
| **Yes** | **No** | **Yes** | 1.9% | 3.3% | 4.2% | 8.3% | 11.3% |
| **Yes** | **Yes** | **No** | 16.0% | 20.0% | 21.4% | 27.2% | 30.6% |
| **Yes** | **Yes** | **Yes** | 14.3% | 20.6% | 23.2% | 33.2% | 39.8% |

## Validation of the routine data and clinical engagement

The demographic profile and basic clinical characteristics of patients in the present study were closely comparable to that reported in a previous large-scale prospective survey of ERCP in which the mean age of participating patients was 65 years, females accounted for 57%, and the suspected diagnosis was ductal stones in 54% and malignancy in 20%.[184] However, all-cause mortality was higher in our study at 5.3% compared with the previous UK survey (2.7%).[184] The latter study may have missed higher-risk cases as informed consent was required – mortality among non-participating patients in the survey was 5.6%.[184] We identified all hospitals (n=66) that participated in the earlier English survey and undertook sub-group analyses for patients treated at participating (n=16,026 patients) and non-participating hospitals (n=24,912 patients). Crude all-cause 30-day mortality was 5.37% for participating hospitals compared to 5.26% for non-participants (no significant difference). We conclude that the higher rate of all-cause death in the present study probably reflects more complete case ascertainment and better inclusion of high risk cases. Table 3.10 shows a comparison of findings from the BSG audit and the NCEPOD data.

**Table 3.10 Comparison of outcomes from previous UK based audits of ERCP practice**

| | BSG AUDIT | NCEPOD | NCEPOD HES | COMMENT |
|---|---|---|---|---|
| **Total no. ercp** | 6910 | Presume 23,606 | 23,606 | |
| **Total ercp deaths** | 121 (30d first ercp)<br>21 procedure related | 237 (30d last ercp) | 381 (30d last ercp) | |
| **Denominator** | 5264<br>(= total number of patients who gave consent for data transfer and follow-up) | 3,853 deaths | 23,606 | **BSG felt their figure represented 20% of the total performed in the UK during the 6month study period in 2004.** |
| **Mortality** | 2.7% 30d<br>0.4% procedure related<br>3.4% 30d if excluded patients included | ? (1% if denominator = 23606) | 1.6% 30d last | |
| **Time scale** | 6 months 2004 | 12 months 01/04/02 – 31/03/03 | 12 months 01/04/02 – 31/03/03 | |
| **Geography** | 5 metropolitan regions (NW, W. Midlands, Trent, N. Thames, S. Thames.).<br>81 hospitals. | England, NI, Wales, Guernsey, IoM, Defence, Independent hospitals (252 NHS and 11 non-NHS hospitals) | England | |
| **Case identification** | Prospective data collection by participating endoscopists. Questionnaire filled out for each consecutive ERCP | Retrospective. Designated local reporters identified all deaths.<br>J38, J40, J41, J42 Within last 6 OPCS codes, within 30d of death | Retrospective. HES<br>J38, J40, J41, J42<br>Within last 6 OPCS codes, within 30d of death | |
| **Death identification** | Designated liaison officer in each within each unit | Retrospective questionnaire to responsible physician at time | HES | |

| | | | | |
|---|---|---|---|---|
| | | of death | | |
| **Inclusions** | All ERCPs performed by participating endoscopists where patient consent obtained. In selected hospitals. | 1,818 (47% all therapeutic endoscopy)<br>237 ercp | Inpatient deaths | |
| **Exclusions** | Non participating endoscopists.<br>No consent from patient.<br>= 1646 | 2,035 (53% of all therapeutic endoscopy)<br>620 = three questionnaire maximum exceeded<br>222 = endoscopy +/or death occurred at a different hospital/duplicates<br>298 miscoded | Outpatient deaths | |
| **Patient type** | IP and OP | IP | IP | |
| **Returns** | 30d follow-up achieved for 92% of 5264 recorded ERCPs. | 66% | Presume 100% | |

Our comparison of anonymous HES data to local data within one Trust confirmed that there was a corresponding case for each recorded death (n=20), implying that the mortality linkage processes between HES and ONS are reliable and that this study is examining genuine clinical cases of post-ERCP mortality. However, one case identified from local data was not identified by HES data. On review of the case notes an electronic report of the ERCP procedure was not present. Instead, the report was hand written in the notes. This may not have been identified by the coding clerks and the ERCP procedure had therefore not been coded. Although most (but not all) units now use an electronic reporting system to record their

endoscopic procedures there are occasional circumstances where an electronic report may not be produced. For example, if a procedure is performed out-with the endoscopy unit without access to the reporting system or, if there are technical problems with the electronic reporting system. Without an easily identifiable report sheet in the notes it will become less likely that the procedure is identified by the clerks. How often this happens is unknown. From our clinician feedback the numbers of procedures identified was generally thought to be accurate and where there was a significant discrepancy it was due to recording ERCP as an outpatient procedure rather than not recording the procedure at all. However, most respondents did have concerns regarding the accuracy of coding and it may be that small numbers of procedures were missed. Our total numbers of procedures do compare well with other studies of workload and in comparison to our total number of procedures analysed this small number of potential omissions would not affect our overall conclusions. Procedures that are missed because an electronic report has not been produced are likely to have been performed in venues other than the endoscopy unit. The common alternative locations for performing ERCP are the hospital main theatres or in the intensive care unit. This group of patients is likely to be sicker than the average ERCP patient with a higher mortality. So, if we have missed these patients our mortality figures are underestimates of the true mortality associated with ERCP and our conclusion that ERCP has a higher mortality than previously quoted holds true.

In total, 114 clinicians from 98 Trusts replied to our questionnaire with several centres nominating one individual to respond – hence feedback was obtained from

65% of institutions. Responses are shown in Table 3.11. Basic ERCP activity data were judged accurate by 66% of respondents but 93% expressed concerns that local coding issues might result in incomplete capture of all ERCPs. It is worth noting that the numbers we sent out were for 11 months of ERCP. This was to allow 30 days of follow-up for mortality calculations. Although this was stated in the information sent out to clinicians it was apparent that some were comparing our 11 month totals to their ERCP numbers over 12 months. Reassuringly, if this is taken into account with some of the figures returned by respondents' then the accuracy of our figures did improve in some cases.

29% of respondents stated that ERCP was performed on more than one site within their Trust. This may have implications for data capture. Two respondents stated that ERCP was not performed at their Trust at all. All ERCP procedures were performed at the local tertiary Trust. One of the consultants did travel and perform ERCP lists at the tertiary Trust and this probably explains why his base Trust had ERCPs coded as occurring there. This base Trust and its handful of wrongly assigned ERCPs were excluded from our final analysis (Trust RK5).

66% took transfers from other Trusts for ERCP at least occasionally with some stating it represented more than 50% of their activity. 80% perform day case ERCP although the frequency that this occurs appeared to vary quite considerably from the free text comments. One respondent stated that day case ERCP was a rare occurrence whereas others stated 30-40% of all cases, others the majority of elective ERCP. 93% will perform ERCP on patients in ITU (including ventilated

patients), although this appeared to happen very rarely from the free-text comments. Generally, this was fewer than a handful of occasions in a year.

Routine local audit of 30-day mortality was being undertaken by 65% of respondents and 74% of specialists indicated that the crude mortality figures derived from HES data appeared valid for their unit. This was corroborated by figures provided by some respondents. For example, their calculated 30-day mortality was 5.36%, our HES derived mortality for that Trust was 6.2%, another Trust stated 3.4%, our data showed 4.2% and 7.6% vs. 10% in another Trust. 77% of respondents agreed that the crude unadjusted mortality data was potentially useful to local teams and 91% wished to have routine access to more detailed information on any local cases of 30-day mortality that appear in the dataset. However, 45% suggested modifications to the pilot analyses and this feedback informed the final analytical plan. Of those suggesting modifications to the pilot analysis (n=53), key themes were measurement of procedure-related mortality, as opposed to all-cause mortality (23.7%); a need to adjust crude all-cause mortality rates for case-mix (17.5%), procedural complexity (6.1%) or patient performance status (2.6%); and the suggestion to extend linkages to registered cause of death (10.5%).

We received 116 free text comments from 53 respondents about how institutional-level all-cause mortality data might be misinterpreted or used. Concerns relating to lack of case-mix adjustment were the main focus (21.1%). Other concerns included inaccuracy of local data coding (8%); the potential to unfairly penalise low volume units (9%); the potential for such data to discourage intervention in high risk or palliative cases ('risk aversion') (6%) and misinterpretation of crude mortality as a

marker of ERCP procedure quality by the public or media (6%). There were also encouraging comments supporting the use of this type of data to promote transparency and honesty in healthcare; to highlight good practice as much as identify poor performance. There was support for this type of data analysis to improve standards.

## Institutional-level analysis

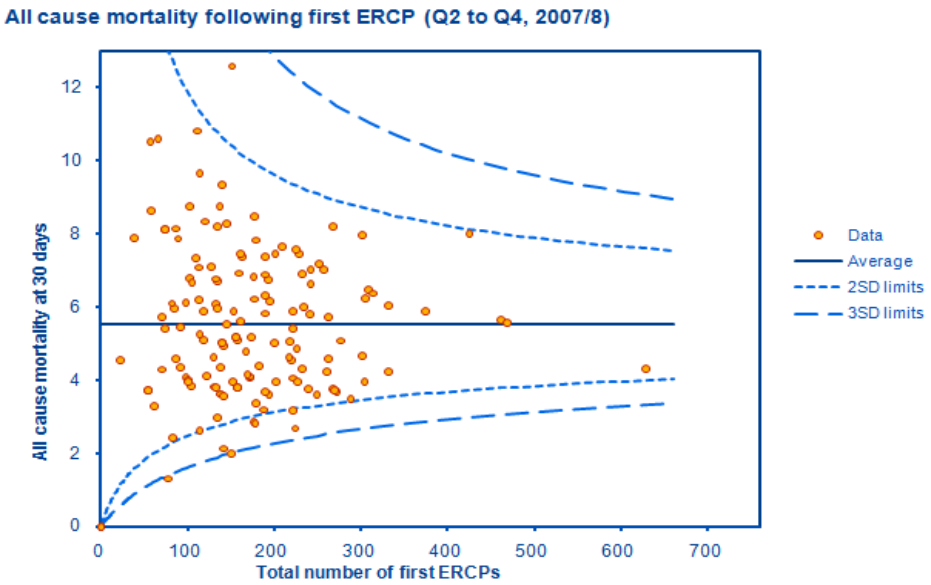
NHS Trusts vary in size from single-site district general hospitals to larger organisations which provide acute services on several hospital sites. Unadjusted all-cause mortality was plotted against institutional case volume in a funnel plot for each data year with confidence limits around the national mean (Figure 3.2a and 3.2b). Without adjustment for case-mix variables we observed a typical funnel-shaped distribution and no evidence of over-dispersion. No Trust lay outside the outer 99.8% binomial confidence limit in any data year, nor did any single Trust occupy a position outside the 95% limit in both data years. Regression analysis showed no significant trend between procedure volume and all-cause mortality risk at 30 days ($r=-0.05$; $p>0.05$; $n=150$ Trusts).

Using the national-level mortality risk from the look-up table (Table 3.9) and analysing the pooled data from both years we performed standardisation of Trust-level all-cause mortality rates by calculating expected deaths for each Trust according to their local case mix based on age groups, admission status, cancer diagnosis and our binary co-morbidity variable. 'Excess' deaths were calculated by subtracting expected deaths from observed deaths in each sub-group and the institutional mortality rate standardised by conventional methods using the

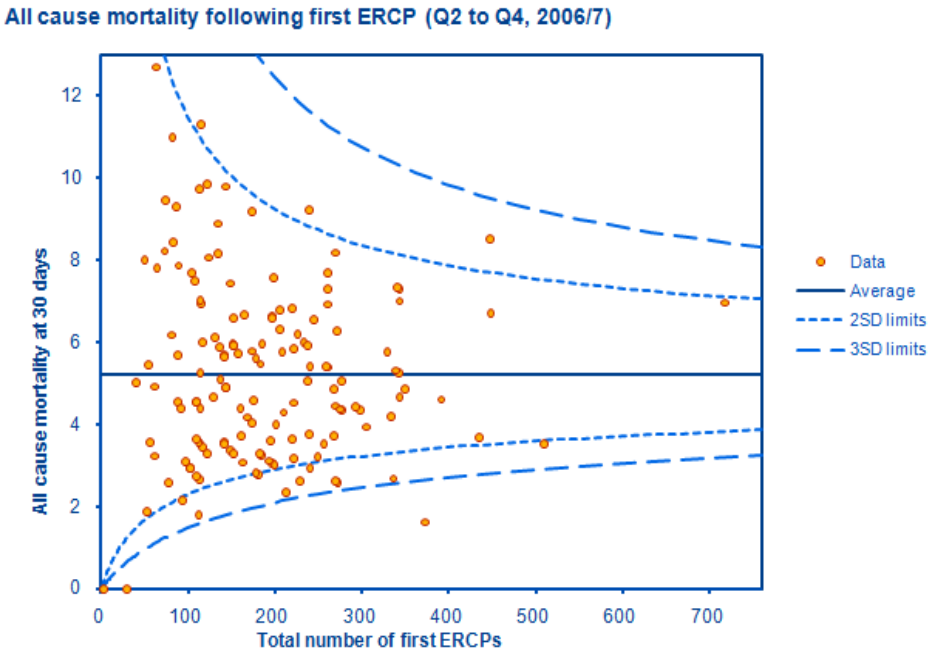
estimated excess (or deficit). The unadjusted (Figure 3.2c) and case-mix adjusted rates were plotted (Figure 3.2d). As with the unadjusted crude rates, the distribution of case-mix adjusted data showed a typical funnel-shape, with all Trusts lying within the arbitrary outer statistical confidence limits (3 standard deviations, SD) but with a greater degree of clustering close to the national mean.

**Figures 3.2 a-d Funnel plots for all-cause mortality following first ERCP**

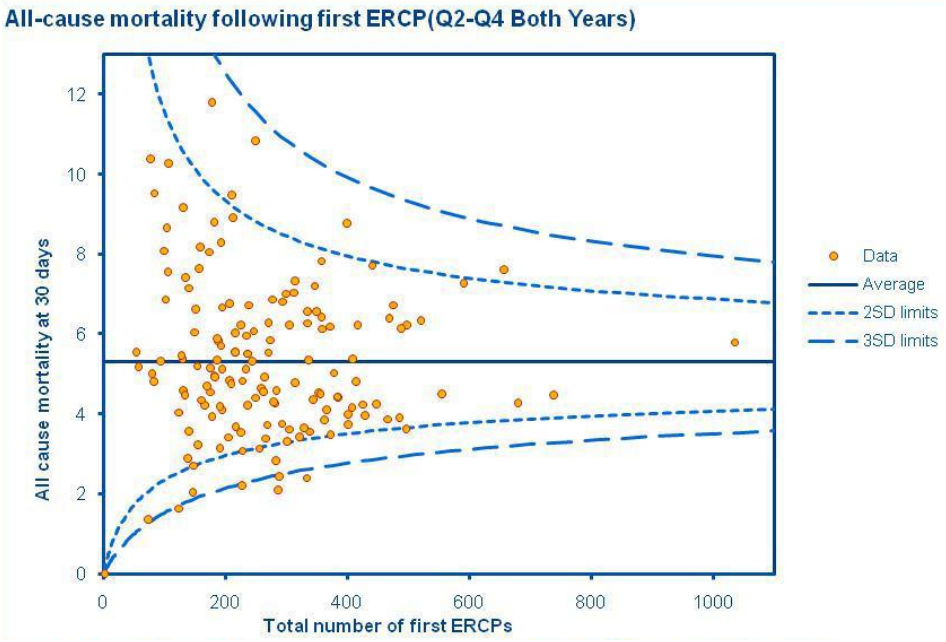
**a. 2007-2008**



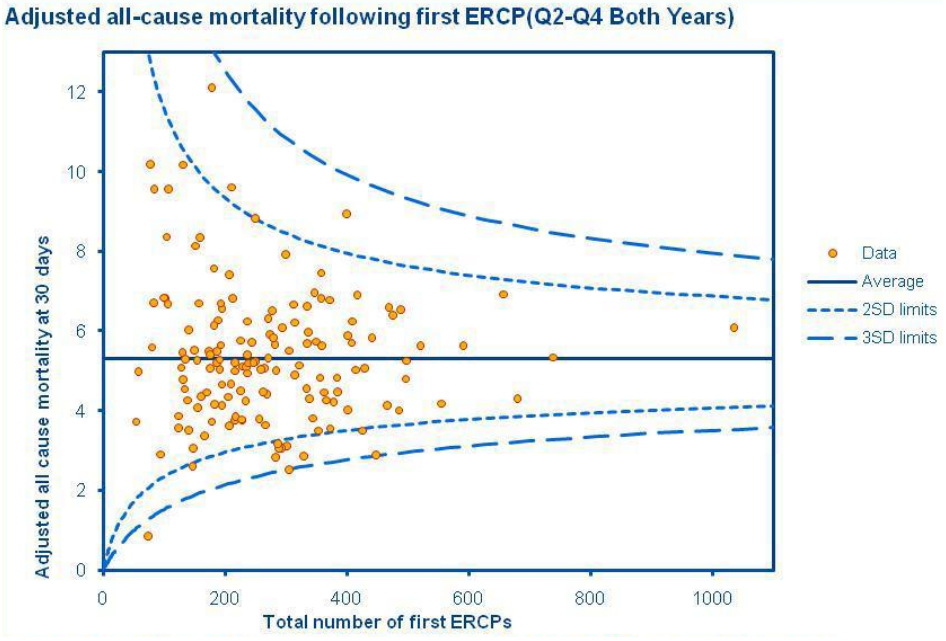

**b. 2006-2007**



### *c. Combined 2006-2008*




### *d. Adjusted all-cause mortality following first ERCP 2007-2008*




(Funnel plots constructed using Association of Public Health Observatories. Analytical tools for public health: Funnel plot for proportions and percentages [156])

**Table 3.11 Responses to Clinician Questionnaire**

| S1.1 Does the pilot data for your Trust accurately reflect the volume of ERCP procedures performed annually? |
|---|
| 1. '..on our reporting system 262 procedures over 12mmonths and 221 over 11, 229 in your data' |
| 2. 'The data under estimates numbers by at least 25%' |
| 3. 'Yes in terms of true 30-day mortality (actually 2.3%) but a bit out in terms of numbers (338 last year).' |
| 4. 'Our computerised endoscopy reporting system identifies 396 ERCPs done during this time. Your audit reports 334 ERCPs' |
| 5. 'There have been 3 ERCP procedure shown whereas we carry out nearly 300 ERCPs per year' |
| 6. 'I think the number (261) is an underestimate of around 100.' |
| 7. 'The Trust is an oncology centre serving 3 counties and this may account for slightly higher percentage performed for cancer and the resultant mortality rate.' |
| 8. 'Some Botox injections using side viewing scope may be coded as ERCP but have no risk attached.' |
| 9. 'This matches our internal Web reporting Tool for Endoscopic complications' |
| 10. 'there is approx 85% capture' |
| 11. 'Unisoft system recorded 177 ERCPs for the 12 months from 1/4/06 (not 127)' |
| 12. '180 procedures in time period, not 153 as recorded on your statistics' |
| S1.2 Are ERCPs performed on more than one hospital site within your Trust? |
| 1.'Approx 130 at [xxx hospital] and 230 at [xxx hospital], but a single database, which was sometimes malfunctioning during 2006/07. We now have a new cross-site database, but we still have problems with malfunctioning at times.' |
| S1.3 Does your unit accept transfer of patients for ERCP from other local Trusts? |
| 1. '> 50% of our activity' |
| 2. 'We are a tertiary referral practice for biliary/liver work with a regional liver MDT. A significant proportion do consistent of inter-hospital transfers' |
| S1.4 Does your unit perform day case ERCP (discharge home the same day)? |
| 1. 'Probably a third of our cases are day cases' |
| 2. 'Have done so for a number of years. Virtually all elective ERCP is day case' |
| 3. 'Very rarely' |
| 4. 'However, all 'day case' patients have been coded instead as 'outpatients' until April 2008. These patients are now coded as 'day case' since then.' |
| 5. 'About 40% are discharged home on the same day.' |
| S1.5 Does your Trust undertake ERCP in critically-ill patients requiring intensive care and/or ventilation? |
| 1. 'rarely but occasional severe cholangitis' |
| 2. 'We do significant numbers of these, with over 80 critical care beds in the Trust.' |
| 3. 'max 1-2 per year' |
| 4. 'very very infrequently, if at all' |
| S1.6 Are you aware of local coding or administrative factors that might result in incomplete recording of ERCP procedures? |
| 1. 'Coding notoriously inaccurate and relies on junior doctor recording each intervention' |

| |
|---|
| 2. 'Unclear to use as to whether all inpatient ERCPs are accurately captured, but data that you have presented suggests that if there is a miss rate - it would appear to be small.' |
| 3. '50% of activity recorded, problem across all endoscopy' |
| 4. '.....understand the difference between day cases, in patients and hospital to hospital transfers for the day never being admitted.' |
| 5. '.....patients are not assigned correctly to me as the operator.' |
| 6. 'Historically the Dr Foster statistics for [hospital] suggested a high overall relative mortality, but that has improved recently with better coding of co morbidities. Therefore it is possible that there is incomplete recording of ERCP procedures. However I recorded the same number of procedures during the audit period on my personal database. |
| S1.7 Does your unit perform in-house audit for all-cause mortality within 30-days of ERCP? |
| 1. 'We look for complications rather than 30-day all-cause mortality' |
| 2. 'When done matches the approx 5% figure you give - very rarely procedure related.' |
| 3. 'Audit of 01/07 to 03/8 suggested all-cause mortality of 5.36%' |
| 4. 'The latest audit covers May-Nov 2008. 106 ERCPs. All-cause mortality within 30 days of 3.4% (2 deaths, neither related to procedure).' |
| 5. '24 deaths out of 318 ERCPs in 2006/07 (7.5%)' |
| S1.8 Does the pilot crude mortality figure generated for your Trust appear accurate? |
| 1. 'Probably. Difficult to know as I only monitor in hospital mortality.' |
| 2. 'We had 8 deaths in the 245 cases, one of which was ERCP-related; the others were co-morbidity-or underlying pathology-related.' |
| 3. 'It seems too low' |
| 4. 'ERCP mortality rate appears high most likely because we coded most of our ERCPs as OP rather than day case. Therefore the few ERCPs we do code as inpatients (the sick patients) create an artificially high "mortality". The acceptance of probably sicker/ more complicated patients from other hospitals may be another contributing reason.' |
| 5. 'The number of procedures has been underestimated by 50% as has the mortality figures so percentage 30-day mortality figures about right.' |
| S2.1 Do you think the present analysis represents a potentially useful measure for local Teams? |
| 1. 'It gives no data on complication and cannulation rates which are extremely important.' |
| 2. 'I think mortality is largely related to cause for ERCP (i.e. stenting for cancer) and CBD stone in sick elderly patients with other co-morbidity. I think mortality data should be picked up more accurately through JAG - 6monthly local ERCP audits and 28 day mortality data picked dup on a monthly basis through endoscopy systems.' |
| 3. Despite the less than 100% ascertainment, it gives a reasonable snapshot, and figures are similar to those from the earlier national audit. |
| 4. 'Because as mentioned in your letter needs to correlate with clinical condition. And the inevitable delay in obtaining mortality link prevents timely useful analysis. Would highlight units out of synch, the benchmarking may be useful' |
| 5. 'Really helpful (and reassuring)' |
| 6. 'There are too many other factors. Many patients would like a palliative procedure in spite of their poor short term prognosis and many elderly patients do very well after - it is hard to predict who may die and this measure may put clinicians off attempting these cases' |
| 7. 'As noted, crude mortality figures reflect case-mix and practice. More useful measure of ERCP performance include: primary CBD cannulation rate, repeat procedure rate and direct ERCP complication rate, perhaps as surrogate IP stay length post procedure.' |

| |
|---|
| 8. '1 not broken down by operator 2 we are often doing procedure to give quality of life to ill sometimes terminal patients 3 if this was used it would deter Trusts from performing on ill patients who would benefit but might die 3 it is expensive collecting such data we would rather have more hands on front line staff than data analysts.' |
| 9. 'Yes - this has to be useful. I think there should be a mortality 'norm' - probably of about 2-4%, possibly higher. Lower mortality than this implies inappropriate case refusal which is as bad as inappropriate case performance' |
| 10. 'to highlight the deficiency in coding' |
| 11. 'The case mix will be different, as will the local skill mix and this will undermine the value of comparing data between sites.' |
| 12. 'Crucial to GRS audit.' |
| 13. 'Rather like the Dr Foster mortality statistic, this should encourage careful local review of the cases if the unit is an outlier.' |
| S2.2 The present analysis considers all-cause mortality after any ERCP (including repeat procedures). Would you modify the analysis in any way? |
| 1. 'Inpatient mortality, complication rate, 90-day mortality (for palliative stents)' |
| 2. '...unplanned admissions after ERCP and surgery rates within 30days of procedure...' |
| 3. 'Age standardised data' |
| 4. '...exclude death from underlying diagnosis particularly ca pancreas' |
| 5. 'One would obviously like to know about preventable deaths and complications. If an elderly cholangitic patient dies after a desperate attempt to save their life, it has different implications than if a young woman with SOD succumbs to post-procedure pancreatitis (fortunately, I do not think we have any of the latter). Consequently, one needs to know about pancreatitis, perforation, bleeding and infection caused by the ERCP, if one is to make real sense of the figures. We do not want a more risk-averse attitude to ERCP, which is potentially life-saving in the acute situation.' |
| 6. 'Modify on the basis of indication (Stones, malignancy) and on the basis of first procedure, follow-up procedure and on the basis on any intervention undertaken' |
| 7. 'It would be very nice to know whether these deaths were procedure related complications, tumour deaths or unexpected strokes, infarcts etc. Also whether they were in hospital or at home.' |
| 8. 'Safety could be better assessed with 30-day mortality following sphincterotomy, or failed therapy, or repeat procedure within 30 days.' |
| 9. 'Causes of death are essential to enable any meaningful interpretation of this data' |
| 10. 'Procedure specific mortality. Patients' baseline performance status.' |
| S2.3 Would you be interested in having routine access to more detailed information for any local '30-day mortality' cases identified for your Trust (e.g. age/coded diagnoses/episodes of care/other surgical procedures)? |
| 1. 'Often a very crude measure. I suspect if you plotted crude all-cause mortality for a range of diseases, the variation would be relatively small for different Trusts. UK practice at the end of the day is pretty similar across the land and to draw out differences between Trusts is unlikely unless detail of service delivery is analysed.' |
| 2. 'for all endoscopic procedures' |
| 3. 'if timely data available would be very useful to prevent us all beavering [sic] away with steam driven data/audits' |
| 4. 'Yes - all data are helpful because it is presently inaccurate and needs to get better. It will not improve without being 'aired' or published.' |
| 5. 'I already keep an audit of all my personal ercps with learning points which is more useful |

| |
|---|
| than these sort of very crude statistics' |
| 6. 'I think there is a danger of trying to read too much into this data.' |
| 7. 'To work out why our PAS / HES data is so inaccurate [sic] in addition to providing benchmark standards for future audits' |
| S2.4 Please list any concerns you have about how this sort of data might be misinterpreted or used. |
| 1. 'No concerns. It helps to focus on meaningful outcomes after high risk procedures.' |
| 2. 'If the numbers/coding are not accurate then it reflects poorly on workload/throughput. This data is then used to challenge services by misinformed NHS managers.' |
| 3. 'Low volume centres with good results could be pressured to close or move work away. Care needed to link results with case mix' |
| 4. '....'all-cause mortality following ERCP' may be an example of that: low numbers, wide CIs, possibly measuring the wrong thing, etc.' |
| 5. 'Crude all-cause mortality does not take into account the pre-procedure health of the patient, and at present we often undertake ERCP in patients considered too unwell for surgical procedures. If Trusts get concerned about these figures, there is a danger that doctors will start to refuse to perform ERCP on unwell patients in order to 'improve' the figures for their Trust.' |
| 6. 'It is vital that this sort of information is available accurate open fed back and acted on, on a regular basis.' |
| 7. 'Clearly, there is gross misuse of poor quality data (in League Tables for example) and this makes people worried and unwilling to be open let alone honest. Also, the simplistic interpretation of data by media and politicians (sometimes deliberate misinterpretation dare I say) does not create an atmosphere of openness and candid disclosure. We have to fight against this however, not just for revalidation purposes but because we really need to let practitioners know just how well (or indeed badly) they are performing. And the service needs a mechanism whereby concerns about aspects of service performance can be flagged up. So keep it up as we cannot advance without better quality data.' |
| 8. 'All-cause mortality needs to be interpreted with caution and never be misinterpreted as procedure related mortality.' |
| 9. 'People may not understand small number effect i.e. increase of 25% in mortality year on year may only be 3-4 extra cases but may not be understood by some' |
| 10. 'No concerns only comment. Collection of all-cause mortality as part of the BSG audit was difficult and I think this represents a very helpful contribution. As you allude to in your letter, if you were able to link mortality data to a more comprehensive description of co-morbidity, then it may be possible to model an expected range for mortality that controls for case mix. Whilst you may achieve this with improved coding I suspect it would require some prospective data collection. If such data were collected within units would it be possible to marry it to your outcome data via NHS number? This would form the basis for an interesting study/project in which I would be happy to collaborate.' |
| 11. '.....the case mix needs to be looked at before any comparisons are made.' |
| 12. 'Units risk being labelled 'poor' because they happen to have higher mortality figures resulting from random variation. Year-on Year cumulative data would be more useful.' |

## Discussion

Our analyses show that all-cause mortality after ERCP is explained largely by the natural history of underlying disease. Much of the early mortality occurs in older, acutely unwell (emergency) patients with co-morbid medical conditions and underlying cancer. Palliation of malignant biliary obstruction is a key indication for ERCP and the late-stage presentation of such pathologies makes short-term prognosis poor for many. Our real-world estimates of relatively high 30-day mortality for such cases should not necessarily deter intervention - even in the highest risk groups the majority of cases survive. They are a basis for an informed discussion of risk versus benefit. The information contained within the 'look-up' table provides clinicians with a means to communicate risk with patients and their families to justify intervention, or non-intervention where appropriate.

This analysis of routinely coded data yielded a funnel-shaped distribution of crude mortality statistics when analysed at Trust level, both before and after simple case-mix adjustment. This suggests a process that is under 'control' with variation likely to reflect common-cause factors such as differing case severity and complexity. Such reassuring results probably reflect the training and accreditation systems instituted by the professional society, the British Society of Gastroenterology, over the last 10 years that have ensured a common set of standards for units and operatives providing ERCP services in England[81]. The questionnaire respondents were concerned about coding completeness and accuracy and the fact that HES data does not code the clinical severity of acute illness (e.g. the ASA score, a known predictor of post-ERCP mortality) [129]. Nevertheless, at a national-level routinely

coded variables such as emergency admission status and co-morbid illness have highly significant associations with risk of death and so appear valid as proxy case-mix adjusters. However, the 'constant risk fallacy' is a potential problem when analyses are taken down to institutional level – any given risk factor may not confer the same degree of risk at every centre[25;26].

Coding of co-morbid conditions was limited in this study. Just a quarter of cases had any codes for co-morbid conditions listed in their ERCP episode. This will limit the ability to adjust for case mix when comparing different institutions. Assessing for co-morbid conditions may be improved by linkage of episodes for any given individual using their unique identifier within the HES datasets. The episodes of care prior to the ERCP episode can be identified and may yield more complete coding of co-morbid conditions.

We did not find a correlation between all-cause mortality and procedure volume, in agreement with an American database study of mortality after inpatient ERCP[123]. The monitoring of crude 30-day mortality rates using routine data has been advocated as an institutional performance indicator for interventions that have a high procedural-associated mortality risk[186]. Although the headline mortality risk of 5% after ERCP might suggest a potential for institutional comparisons, the very low rate of mortality among cases lacking risk factors for disease progression (e.g. 0.4% for younger patients with benign indications) suggests a very low signal-to-noise ratio. Whilst the relatively narrow scatter of all-cause mortality across units in England is reassuring for patients, it is important to note that very few deaths are likely to be procedure-related. Specific codes relating to possible technical

complications of ERCP were recorded as the primary diagnosis in only 1.2% of patients who died within 30 days of ERCP (just 0.06% of total procedures, a similar rate to that reported in a single-centre U.S. study)[187]. Our linkage analysis of last-coded primary inpatient diagnosis suggested that it would not be possible to distinguish the effects of natural progression of disease (e.g. pneumonia arising in the setting of advanced cancer) from specific post-procedure complications (e.g. pneumonia as a result of aspiration during ERCP). Clearly, it would not be appropriate to use all-cause mortality as an index of the quality of individual ERCP operator performance – better measures exist[188], such as cannulation rates. Overall mortality rates are more likely to reflect global performance of a team or institution and the underlying disease process.

Nevertheless, clinical engagement in the analysis of routine hospital episode and mortality data offers the potential to better-understand real-world outcomes and to generate information that is meaningful to clinicians and patients in planning care but avoids inappropriate institutional comparisons.

# 4. Percutaneous Endoscopic Gastrostomy

# 4. Percutaneous Endoscopic Gastrostomy


## Abstract

***Background and aims:*** Studies have shown variable outcomes following percutaneous endoscopic gastrostomy (PEG) insertion raising concerns about its widespread use. Subjects who may benefit from PEG may be elderly and/or have significant co-morbidities such that short-term prognosis without intervention is poor. However, PEG insertion is an invasive procedure with associated risks including mortality. Robust data from large multi-centre studies for outcomes following gastrostomy insertion are scarce.

The primary aim of this study was to show that analysis of routinely collected data can be used to assist clinicians, patients and carers in their decision making regarding the risks and benefits of PEG insertion.

Specific aims included the assessment of all-cause mortality at 7 & 30 days following PEG insertion using linkage to Office of National Statistics death certification data; identification of factors associated with crude mortality rates and variation in procedure volume and outcomes at Trust level.

***Methods:*** Care episodes containing procedure codes (OPCS-4) for gastrostomy-related interventions were extracted from our two years of HES data and deaths identified. Diagnostic fields (ICD-10 codes) were analysed for indication and co-morbidity. Factors associated with death were identified by univariate and multiple logistic analyses. Crude mortality rate at each hospital Trust was analysed versus PEG number to explore 'volume' effect.

***Results:*** 30,781 patients had gastrostomy-related procedure codes of which 14,055 were coded with G44.5 ('Fibreoptic endoscopic percutaneous insertion of gastrostomy (PEG)'). Excluding cases with codes for cancer yielded 10,952 PEG patients. The mean age was 68.4 years (16-99 yrs). 51% were male and emergency admissions accounted for 72% of all episodes. Codes for Stroke were found in 40%; Motor Neurone Disease (MND) in 7.2%; Parkinson's Disease in 5.4%; Multiple Sclerosis in 4.9% and Dementia in 7.2%.

All-cause mortality rates were 4.2% at 7 days and 14.6% at 30 days. Binary logistic regression identified the following predictors of death within 30 days of the procedure: Age over 85 years, male sex, emergency admission, motor neurone disease and dementia ($p<0.03$ for all). In elderly patients (85+) during emergency admissions, dementia was associated with 7-day mortality of 14.6% compared to 7.8% in stroke. No correlation for 30-day death versus PEG volume was identified at NHS Trust level (Pearson $r=0.04$).

***Conclusions:*** Hospital Episode Statistics data allow national-level analysis to provide real-world estimates of prognosis in subjects selected for PEG in England and identify factors associated with all-cause death.

## Introduction

This study aims to:

1. Determine feasibility of analysing all-cause mortality at 7 & 30 days following PEG insertion using Hospital Episode Statistics (HES) linked to Office of National Statistics (ONS) death certification data
2. Identify factors associated with crude mortality rates.
3. Assess variation in procedure volume and outcomes at Trust level

### *Background*

Percutaneous endoscopic gastrostomy (PEG) is a method by which nutrition can be maintained via the enteral route in patients whose oral intake is inadequate and who may otherwise require intravenous feeding or repeat insertions of naso-gastric feeding tubes. First described in 1980[189], studies have shown variable outcomes following PEG insertion raising concerns about its widespread use. In 1990 over 85,000 patients in the U.S. aged 65 years and older were discharged from hospitals with a gastrostomy. This figure includes around 1% of the US population aged over 85 years[190]. Percutaneous gastrostomy tube insertion is indicated in patients who are likely to need enteral feeding for more than four weeks[191]. There are complex ethical issues surrounding enteral feeding that need to be taken into consideration before PEG tubes are inserted. Patients having PEGs inserted are, by definition not 100% fit and healthy. Guidelines as to who is appropriate for PEG feeding vary and are changing[192]. In the UK indications for PEG insertion include stroke, other neurological conditions, head and neck cancers, intestinal failure requiring supplementary intake and head injury. In these circumstances PEG feeding

improves the quality of life, enables people to be discharged home and may prolong life[191;193-195]. Guidelines published by the Royal College of Physicians in 2008 recommended that gastrostomy feeding should be considered for stroke patients who are unable to tolerate naso-gastric feeding within the first four weeks; are unable to maintain adequate oral intake at 4 weeks; and, those who are at long-term, high risk of malnutrition. Swallowing will be affected in up to 40% of stroke patients with 30% having evidence of poor nutrition, malnutrition and dehydration after their stroke. All these factors are associated with worse outcome[196]. For those with head and neck cancers, pre-operative PEG feeding can optimise the patient for surgery, improving outcomes[197-201].

Gastrostomy tubes may be placed endoscopically, surgically or radiologically (radiologically inserted gastrostomy or 'RIG'). All methods are invasive and have associated risks, including mortality. This study generally confines itself to endoscopically placed gastrostomy tubes (PEG) which is the most common and widely used method of insertion. Complications can relate to the endoscopy, to the percutaneous insertion itself or later complications such as tube displacement, tube blockage and discomfort due to tube position. Complications can also arise from the process of enteral feeding – reflux and aspiration, diarrhoea, bloating and potentially more dangerous, metabolic disturbance including refeeding syndrome[202]. All these factors contribute to the mortality associated with PEG insertion but do not explain all deaths following the procedure. Indeed these events probably only explain a very small number, with procedure related mortality previously reported as below 1%[197;203].

There are many studies looking at outcomes following gastrostomy. However, these are generally retrospective, small or single centre. Follow-up is limited and often no more than 30 days. Although recurrent themes do emerge, robust data from large multi-centre studies for outcomes following gastrostomy insertion in particular groups of patients are scarce.

Reports of 30-day mortality following PEG insertion varies widely with some studies suggesting rates of over 25%[204]. Other studies suggest much lower 30-day mortality rates of under 10%[205;206]. There is evidence that mortality is higher in patients who have their PEG insertion whilst hospitalised for acute illness compared to those admitted electively for the procedure[207-209]. The NCEPOD report of 2004 looked at deaths in England within 30 days of a PEG procedure. They considered that nearly 20% of these procedures were probably futile with 43% deaths occurring within 1 week of the procedure[52;210]. Of note, the NCEPOD report used codes pertaining to gastrostomy problems, replacement and removal as well as specific insertion codes to identify PEG procedures for their mortality analysis. Thus, a (small) number of the deaths identified in the NCEPOD report probably did not occur within 30 days of a PEG insertion, but within 30 days of a post insertion event.

The National Patient Safety Agency (NPSA) issued guidance on gastrostomy insertion following reports of 22 serious incidents following gastrostomy insertion, including 11 deaths, between 2003 and 2010[211].

Studies have often been based on single centre cohorts of patients and accepted indications for PEG insertion vary from country to country. The largest study used data from the US Medicare claims database to perform a retrospective cohort

study. They looked at 81,105 cases of gastrostomy insertion from 1991. The in-hospital mortality was 15.3% whilst the overall 30-day mortality was 23.9%. Mortality at 1 and 3 years was 63% and 81.3% respectively[212]. Another large study of PEG outcomes to date was a retrospective study using data from two large electronic databases from Veteran's Affairs in the United States[213]. This looked at 7,369 patients having PEG insertions over two years in the early 1990s and followed them up for a period of three years. This cohort of patients were mostly male (98.6%), with ages ranging from 18 to 102 years. Nearly 20% had cerebrovascular disease, 29% had other neurological disease and 16% had head and neck cancer. The in-hospital mortality was 24%. A figure for 30-day mortality was not provided but figures at 1, 2 and 3 years were 59%, 71% and 77% respectively. Age was found to be the important determinant for mortality. Other co-morbid conditions (i.e. not indications for PEG insertion) were not assessed. A meta-analysis of five cohort studies confirmed that the majority of older patients (>65 years old) who undergo PEG insertion did not survive 12 months[214].

Co-morbidity clearly affects outcomes with studies showing higher mortality in populations with a higher proportion of cancer patients. Deaths are often related to the underlying diagnosis rather than the procedure itself. Pre-procedure assessment of the patient by the Nutrition team / gastroenterologist / endoscopist can reduce PEG mortality by excluding those patients whose underlying diagnosis makes their life expectancy too short to benefit from PEG insertion[215]. Local audit at my base hospital (University Hospital Aintree, Liverpool, UK) showed a 30-day mortality of 17% in 2003-2004. Since then a more stringent pre-procedure

assessment of patients referred for PEG has been introduced and the 30-day mortality has fallen to 9%.

A British retrospective study found that a tenfold rise in number of PEG insertions over 10 years was accompanied by a threefold increase in 30-day mortality from 8% to 22%. Multivariate analysis showed three independent predictors of 30-day mortality: pre-procedure fast of 7 days or more, albumin below 30 and history of cardiac disease. However, confidence intervals were wide (though none including 0 or 1), and overall numbers small (particularly in the first cohort). What they did note was that the proportion of PEGs inserted for non-evidence based indications e.g. dementia and pneumonia, had increased (p=0.048) which is obviously of concern[206]. Outcomes following PEG insertion in patients with severe dementia are known to be poor, with reported 30-day mortality rates of over 50% [216].

In the US, Kobayashi et al looked at outcomes for all patients referred for PEG insertion to identify factors predictive for survival[166]. This was a prospective study with 12 months of follow-up including a total of 67 cases referred for PEG assessment. The 30-day mortality in the 50 patients who eventually underwent PEG insertion was 20%. Interestingly, 5 patients died within 7 days of the referral being made, 3 before they had even been assessed by the Gastroenterology team, underlining the importance of physician education regarding timing and indication for PEG insertion. The only factor significantly associated with mortality (Kaplan-Meier and multivariate analysis) post-PEG was a Charlson Index of 4 or more. The Charlson Index is a validated measure of co-morbidity used to predict mortality in longitudinal studies[142]. Low albumin levels were not found to be associated with

mortality. 62% of patients referred for PEG in this study were fully dependent in all ADLs with dysphagia secondary to dementia the primary indication for PEG insertion in 10 patients. This may differ from UK institutions and indeed is likely to change in the US as there is good evidence that PEG insertion in severe dementia is associated with much worse outcomes and is not appropriate. In this study 14% patients regained their swallow and had their PEG removed during follow-up. Indications for these PEGs were stroke (n=2), other neurological disorder (n=1), head and neck cancer (n=2), aspiration pneumonia (n=1) and near drowning (n=1).

Few studies have looked at the effect of PEG feeding on quality of life. Some have confirmed improved nutritional status in patients following PEG feeding[217] and improvement in swallow function sufficient to allow removal of PEG in up to 16% of patients[166;204]. The 'Feed or Ordinary Diet (FOOD)' Trial reported that early enteral feeding reduced the risk of dying following stoke, although functional outcome at 2-3 weeks was better with naso-gastric tube feeding than with PEG feeding[218]. Other studies have confirmed superiority of PEG feeding over naso-gastric feeding in the longer term[217;219].

Advancing age and its association with higher mortality has been confirmed by other studies. A retrospective study showed a 1.9% increased risk of dying before discharge for each additional year of age[220]. This study also found being married; mechanical ventilation and dialysis were associated with in-hospital death on multi-variate analysis. These findings may say more about US healthcare practices than anything else but the overall 30-day mortality of 22% and in-hospital mortality of 11% are in keeping with other studies. Being married generally reduces mortality

but Smith et al suggest that a spouse is a surrogate decision maker who will make the choice to withdraw care. Conversely, patients without a spouse or 'Next of Kin' are less likely to seek medical care and won't have anyone requesting PEG insertion.

The decision to insert a gastrostomy is a complex one. Careful patient selection is vital if outcomes are to be in the best interests of the patient. Evidence based guidance; using robust data will assist physicians, patients and relatives, in assessing the risks and benefits of insertion for an individual.

Doctors, patients and carers require realistic expectations of outcome when considering PEG placement. Subjects who may benefit from PEG may be elderly and/or have significant co-morbidities such that short-term prognosis without intervention is poor. We hope to show that a national database of routinely collected data can provide useful and robust data about outcomes following PEG insertion that can be used by clinicians to guide their decision making and enable them to fully inform patients and relatives regarding the risks and benefits of such procedures.

## Methods

From our master files for 2006/07 and 2007/08 (see ERCP Method section: The Master Datasets), episodes of care (including day cases) containing OPCS-4 procedure codes for gastrostomy-related interventions were extracted and deaths within 7 and 30 days identified. Diagnostic fields (ICD-10 codes) were analysed for diagnosis and co-morbidity. Factors associated with death were identified by univariate and multiple logistic analyses. Crude mortality rate at each hospital Trust was analysed versus PEG number to explore 'volume' effect.

### The PEG Datasets

Cases of PEG insertion were identified using the 13 OPCS codes listed in Table 4.1. For the initial data extraction all codes pertaining to gastrostomy insertion were used. However, for the final analysis we looked only at episodes containing the G445 code. This is the only code that specifically describes endoscopic percutaneous insertion of a gastrostomy tube. Some of the other codes do not specify the exact method of insertion and could therefore be used to describe surgical and radiological insertions as well as the standard endoscopic method. Remaining codes describe gastrostomy tube associated events such as replacement, displacement, removal, blockage or other problems. The primary aim of this study is to assess mortality following insertion of PEG therefore it was felt appropriate to exclude these other codes from the final analysis.

**Table 4.1 List of OPCS codes used to select PEG and PEG related procedures**

| Code | Definition |
|---|---|
| **G34.1** | Artificial opening into stomach, Creation of permanent gastrostomy |
| **G34.2** | Artificial opening into stomach, Creation of temporary gastrostomy |
| **G34.3** | Artificial opening into stomach, Reconstruction of gastrostomy |
| **G34.4** | Artificial opening into stomach, Closure of gastrostomy |
| **G34.5** | Artificial opening into stomach, Attention to gastrostomy tube |
| **G34.8** | Artificial opening into stomach, Other specified |
| **G34.9** | Artificial opening into stomach, Unspecified |
| **G36.1** | Other repair of stomach, Gastropexy nec |
| **G36.3** | Other repair of stomach, Closure of abnormal opening of stomach nec |
| **G36.8** | Other repair of stomach, Other specified |
| **G36.9** | Other repair of stomach, Unspecified |
| **G44.5** | Fibreoptic endoscopic percutaneous insertion of gastrostomy (PEG) |
| **G44.8** | Other fibreoptic therapeutic endoscopic operations on upper gastrointestinal tract, Other specified |

The syntax used in SPSS to produce the datasets can be found in Appendix 7.1. PEG codes were identified in each of the 12 procedure fields and those episodes of care copied into a new data set corresponding to each field. This process produced 12 files with a line of data for each PEG procedure patient, identified by their unique HESID. These files were named 'PEGextractposition1', 'PEGextractposition2' and so on, up to 'PEGextractposition12'. Where a patient had a PEG code in diagnostic code position 1 and 4 for example, there would be an entry in both the files 'PEGextractposition1' and 'PEGextractposition4'. At this stage this would occur regardless of the dates associated with the two codes.

The aim is to create one file containing a line of data for each PEG procedure. Before this can happen we have to identify which codes pertain to an individual procedure. Each procedure code has a date held within the corresponding 'OPERDATE' field. If PEG codes have the same date and HESID then they are

presumed to represent one PEG procedure and will be represented by one line of data in the final dataset. It is highly unlikely a patient would undergo more than one PEG insertion in a day. If PEG codes for the same HESID have different dates then the patient identified by that HESID had PEG procedures on two different days and would therefore have two lines of data in the final dataset.

In each extract the corresponding OPERTDATE variable was copied and the duplicate field renamed to create a '**PEGDATE**' variable (i.e. From the 'PEGextractposition1' file, copy the 'OPERDATE1' column and paste into new column and rename **PEGDATE**; in 'PEGextractposition2' copy and paste OPERDATE2 to create **PEGDATE** variable etc).

A further new variable must be created before merging the datasets. This is **'PEGPOSITION'** and will aid with the removal of duplicate entries (see below). In 'PEGextractposition1' the 'PEGPOSITION' variable equals 1 for all episodes, in 'PEGextractposition2' it equals 2 for all episodes, in 'PEGextractposition3' it equals 3 and so on.

The 12 files can then be merged (see below). A copy of the 'PEGextractposition1' file is made before merging so that at the end of the process we still have all 12 individual 'PEGextractposition' files, as well as the final merged data file. This is a safety measure to allow cross-checking of totals and allow the process to be repeated if discrepancies are found.

To merge the files, first open 'PEGextractposition1'. Use the SPSS function '**MERGE FILES'** by **'ADDING CASES'** and merge data from the 'PEGextractposition2' file then

position3 etc. Check totals as you proceed and compare with sum of individual position files. To merge, all files must have identical variables in the same order (usually ascending) and format e.g. numeric, string, date format. If these differ for a particular variable, it won't merge.

Once the files are merged (do data years separately) they are saved as '**PEG0607MERGEDextracts.sav'** and **'PEG0607MERGEDextracts.sav'.** These files contain all episodes containing a PEG procedure code in each data year.

### *Removing duplicates*

At this stage the files contain a line of data for each PEG code. We have to delete rows of data attached to codes that pertain to the same procedure i.e. have the same date, to leave us with a row of data for each procedure.

First, the dataset must be ordered using the **'Sort'** function in SPSS to sort data in ascending order by HESID, PEGDATE and PEGPOSITION. Then, 'Identify duplicate cases' by matching for HESID then PEGDATE. This will label identical duplicate episodes as '0', with '1' identifying unique or first episodes. By using 'Select cases' where 'primaryfirst' = 1 data can be copied into a new dataset: 'PEG0607DUPLICATESREMOVED'. This file contains all separate PEG episodes for each patient with one row of data for each different episode. By sorting the data according to 'PEGPOSITION' the final dataset will contain the codes used in the highest procedure position and should therefore contain the most patient information. The secondary codes used on the same date will be contained within that row of data.

### *Deletions*

Initial data cleaning to exclude paediatric cases, invalid age data, and inappropriate admission types e.g. 'admitted ante-partum' is described in the ERCP Chapter 'Method' section. No Trusts were excluded from the PEG analysis. It was expected that there would be substantial variation in the number of PEG procedures performed over 12 months across different institutions with very low numbers not necessarily indicating missing or inaccurate data.

Further data cleaning of the merged PEG datasets was performed to eliminate episodes with PEG procedures dates outside the target time period or outside the extracted episode time period (i.e. did not occur in that episode). Episodes with PEG procedure dates after the date of death were deleted.

## Additional Variables

Additional variables were added to the PEG dataset to allow further analysis. Many of these are described in the ERCP Method section. Those variables specific for the PEG analysis are described in Table 4.2.

## Final PEG Datasets - Exclusions

As we wanted to analyse only gastrostomy insertions rather than all PEG related procedures, we elected to include only episodes containing the OPCS code G445 in our final dataset. This meant we could lose some gastrostomy insertion episodes where insertions were coded without the G445 code (a minority) but our data would not be contaminated with episodes of care relating to post-insertion events.

The commonest scenario for a patient with cancer to be having a PEG tube inserted is a patient with a head and neck cancer who is having the gastrostomy inserted

prior to them undergoing major surgery and /or radiotherapy. This enables them to maintain oral nutrition throughout their treatment. The PEG will be inserted during an elective admission and will often be removed in the months following completion of treatment. This population is entirely different to the vast majority of PEG patients who have lost the ability to swallow safely due to an acute or chronic neurological process and are having their PEG inserted during an emergency admission. For these reasons our final dataset was reduced further by excluding all cancer cases.

**Table 4.2 Additional variables added to create final PEG dataset**

| Variable name | Description |
|---|---|
| **FIRSTPEGEPISODE** | 1 = First PEG code containing episode in data year; 0 = Repeat PEG episode. Created by matching on HESID after sorting data on HESID and PEGDATE |
| **LASTPEGEPISODE** | 1 = Last PEG episode in the data year – see above |
| **EPISODEsequence** | 0 = Only PEG episode in data year<br>1 = First PEG episode in data year where patient has more than one episode; 2 = Second PEG episode in a sequence of more than one; 3 = Third episode; etc |
| **DAYSTOPEG** | Days from admission date to PEGDATE calculated using the Date and Time Wizard function in SPSS |
| **PEGDATE** | Date of PEG procedure |
| **DAYSTODEATH** | Days from PEGDATE to DEATHDATE |
| **DEATH7** | Marker to indicate death less than 8 days after PEGDATE |
| **DEATH30** | Marker to indicate death less than 31 days after PEGDATE |
| **STROKE1-17** | 1=stroke code present in position 1-17. For this analysis, codes selected to identify a stroke were those used in Sundararajan et al's[177] version of the Charlson Index. See **Appendix 7.1 - PEG Syntax.** The method for deriving marker variables is described |

| | |
|---|---|
| | in the ERCP Chapter, method section |
| **STROKEMARKER** | Indicates a stroke code is present in any of the diagnosis code fields |
| **SUMSTROKE** | Indicates the total number of stroke codes present from a care episode |
| **G445** | Indicates the presence of the G445 code in any of the procedure code fields |
| **NONSTROKENONCANCERCOMORB** (Derived via NONSTROKENONCANCERCOMORB1-17 as above for STROKE) | Indicates the presence of a co-morbidity code that is not stroke or cancer related. See **Appendix 7.1 - PEG Syntax** |
| **DEMENTIA** (Derived via DEMENTIA1-17) | Indicates a dementia code is present in any of the diagnosis code fields. See **Appendix 7.1 - PEG Syntax** |
| **MND** (Derived via MND1-17) | Indicates a code for motor neurone disease is present in any of the diagnosis code fields. See **Appendix 7.1 - PEG Syntax** |
| **MS** (Derived via MS1-17) | Indicates a code for multiple sclerosis is present in any of the diagnosis code fields. See **Appendix 7.1 - PEG Syntax** |
| **PARKINSONS** (Derived via PARKINSONS1-17) | Indicates a code for Parkinson's disease is present in any of the diagnosis code fields. See **Appendix 7.1 - PEG Syntax** |

## Statistical Analysis

The Hospital episode data were stored, manipulated and analysed using the SPSS statistical package (SPSS Inc., Chicago, USA). National-level analyses of factors associated with all-cause death were identified by univariate analysis and multiple logistic regression models. Funnel plots of institutional-level data were generated

using analytical tools provided by the Association of Public Health Observatories.[156] Significance was set at $p<0.05$.

### *Univariate analysis*

Analysis was performed to assess the effects of the following variables on mortality following PEG insertion at 7 and 30 days:

- admission method type
- age and gender
- presence or absence of co-morbid conditions
- presence of stroke and /or dementia

### *Multiple logistic analysis*

All variables found to be significant at the univariate level were then assessed for effect as part of a multiple logistic regression analysis. Again this was performed using SPSS.

### *Volume vs. Mortality effect*

Crude mortality rate at each hospital Trust was analysed versus PEG number to explore 'volume' effect. At Strategic Health Authority (SHA) level the proportion of patients with a particular diagnosis e.g. dementia, who had a PEG inserted was also assessed for effect on mortality rates.

## Results

Following initial data extraction from the raw HES data sent from Northgate we had 10,753,151 episodes of care (9,207,734 admissions) for 2006/07 and 11,296,023 episodes of care (9,703,791 admissions) for 2007/08. From this data we identified 30,781 unique episodes of care pertaining to one of the 13 PEG procedure codes across the two years. Further processing and deletion of erroneous data (Table 4.3) gave 14,055 episodes of care containing the G445 code. Analysis was further restricted to 10,952 episodes of care with no cancer codes present.

**Table 4.3 Total deletions from PEG dataset**

| Deletions by EPIKEY 200607 | n |
|---|---|
| PEGDATE 1600 | 54 |
| PEGDATE B4 01/04/06 | 633 |
| PEGDATE AFTER 31/03/07 | 1 |
| PEGDATE B4ADMIDATE | 6 |
| EPIEND 1582 | 9 |
| DISMET 4 WITH NO DOD | 35 |
| **TOTAL DELETIONS** | **738** |

### All PEG codes

133,126 diagnostic codes were contained within these 30,781 episodes. However, this total contained only 3413 unique codes. Most codes (3184, 93.3%) were used fewer than 100 times but accounted for nearly a quarter (23%) of all diagnoses. Nearly a thousand codes were used only once, representing 0.72% of all diagnoses. The most commonly used diagnostic code was for 'Essential (primary) hypertension', followed by 'Attention to gastrostomy', 'Dysphagia', 'Atrial fibrillation and flutter', 'Cerebral infarction, unspecified', 'Pneumonitis due to food

and vomit', 'Non-insulin-depend diabetes mellitus without complication', 'Personal history of diseases of the circulatory system', 'Urinary tract infection, site not specified' and 'Epilepsy, unspecified'. Together, these 'Top 10' diagnostic codes accounted for 22.3% (29,671) of all the diagnoses made.

Using either the broader HES coding groups or a more detailed grouping system (see Tables 4.4a&b) the most common group of codes used were the 'Z' codes. These codes represent 'factors influencing health status and contact with health services'[140]. They accounted for 16.5% of all diagnoses. Nearly 75% of all diagnoses were covered by the following categories of codes: 'Z' codes; Diseases of the digestive system; Diseases of the circulatory system; Diseases of the nervous system; 'R' codes; Diseases of the respiratory system and Neoplasms. ('R' codes represent 'symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified). Infection accounted for 7264 diagnoses (5.46% of the total) using 247 individual codes. Cancer codes accounted for 5.9% of all diagnoses.

**Tables 4.4a+b Frequency of diagnostic codes**

**a. By HES categories**

| Code categories (HES categories) | Count of individual codes | Sum of Total | % of all diagnoses |
|---|---|---|---|
| Factors influencing health status and contact with health services | 260 | 21959 | 16.49 |
| Circulatory system | 249 | 21696 | 16.30 |
| Digestive system | 260 | 15680 | 11.78 |
| Symptoms, signs & abnormal clinical and laboratory findings | 179 | 10640 | 7.99 |
| Diseases of the nervous system | 212 | 10568 | 7.94 |
| Respiratory system | 125 | 10151 | 7.63 |
| Neoplasms | 251 | 7860 | 5.90 |
| Endocrine, nutritional & metabolic | 144 | 6590 | 4.95 |
| Injury, poisoning & other consequences of external causes | 394 | 6332 | 4.76 |
| Infectious & parasitic diseases | 172 | 5535 | 4.16 |
| Mental & behavioural disorders | 145 | 3487 | 2.62 |
| Genitourinary | 128 | 3289 | 2.47 |
| External causes of morbidity and mortality | 246 | 2751 | 2.07 |
| Musculoskeletal and connective tissue | 191 | 2211 | 1.66 |
| Skin & subcutaneous tissue | 79 | 1336 | 1.00 |
| Diseases of the blood & blood forming organs, disorders of immune mechanism | 66 | 1318 | 0.99 |
| Eye & adenexa | 70 | 566 | 0.43 |
| Benign neoplasm | 101 | 489 | 0.37 |
| Congenital | 107 | 475 | 0.36 |
| Ear & mastoid | 31 | 189 | 0.14 |
| Perinatal | 2 | 2 | 0.00 |
| Pregnancy, childbirth & puerperium | 1 | 2 | 0.00 |
| **Grand Total** | **3413** | **133126** | **100** |

**b. By detailed bespoke categories**

| Code categories (bespoke) | Count of individual codes | Sum of codes | % of all diagnoses |
|---|---|---|---|
| Z codes | 260 | 21959 | 16.49 |
| Gastroenterological | 236 | 15818 | 11.88 |
| Cardiovascular | 178 | 13964 | 10.49 |
| Neurological | 261 | 10723 | 8.05 |
| R codes | 179 | 10640 | 7.99 |
| Cancer | 251 | 7860 | 5.90 |
| Stroke | 30 | 7343 | 5.52 |
| Infection | 247 | 7264 | 5.46 |
| Respiratory | 68 | 6816 | 5.12 |
| T codes | 165 | 3905 | 2.93 |
| Renal | 94 | 3212 | 2.41 |
| Diabetes | 31 | 2827 | 2.12 |
| S codes | 229 | 2427 | 1.82 |
| Rheumatological | 198 | 2425 | 1.82 |
| Psychiatric | 121 | 2140 | 1.61 |
| Y codes | 109 | 2042 | 1.53 |
| Pneumonia | 19 | 1928 | 1.45 |
| Dementia | 21 | 1574 | 1.18 |
| Haematological | 63 | 1303 | 0.98 |
| Electrolyte imbalance | 10 | 1186 | 0.89 |
| Metabolic disease | 36 | 1067 | 0.80 |
| Endocrine (excl diabetes) | 40 | 972 | 0.73 |
| Dermatological | 62 | 811 | 0.61 |
| Nutrition | 26 | 498 | 0.37 |
| W codes | 63 | 492 | 0.37 |
| Benign tumours | 101 | 489 | 0.37 |
| ENT | 28 | 339 | 0.25 |
| Eye | 42 | 329 | 0.25 |
| Congenital | 84 | 242 | 0.18 |
| Max-Facial | 31 | 146 | 0.11 |
| X codes | 40 | 128 | 0.10 |
| Gynaecological | 40 | 89 | 0.07 |
| V codes | 34 | 89 | 0.07 |
| Eating disorders | 5 | 34 | 0.03 |
| Unclassified | 8 | 27 | 0.02 |
| Delirium | 3 | 18 | 0.01 |
| **Grand total** | **3413** | **133126** | **100** |

## Final Analysis on G445 coded procedures only

This rest of the results presented here relate only to patient episodes containing the code G44.5 ('Fibre optic endoscopic percutaneous insertion of gastrostomy'). After excluding patients with cancer, 10,952 PEG patients were included in the final analysis. (Table 4.5)

Male patients accounted for 51%. The mean age for all patients was 68.4 years with a range from 16-99 years of age. Over two-thirds (71.7%) of patients had their PEG inserted during an emergency admission.

The diagnostic codes within the reduced dataset were assessed for all patients. All diagnostic code positions were analysed and all codes within each position were totalled. A stroke code was found in 40.1% of patients; a code for motor neurone disease (MND) in 7.2%; Parkinson's disease in 5.4%; multiple sclerosis in 4.9% and dementia in 7.2%. These disease states thus incorporated 64.8% of patients. The remaining 35.2% of patients did not have a code within any of these groups, which is in keeping with other studies[221].

31.6% of cases had at least one co-morbidity coded (using the modified Charlson definitions – see ERCP chapter).

**Table 4.5 Patients characteristics and crude all-cause mortality for PEG insertions performed in England 2006-2008**

| | 2006-08 |
|---|---|
| **Patients, n** | 10,952 |
| **Female gender, % (n)** | 49% (5,366) |
| **Age, mean (range)** | 68.4 years (16-99) |
| **Admission type, % (n)** | |
| **Elective** | 28.3% (3,099) |
| **Non-elective (emergency)** | 71.7% (7,853) |
| **Diagnosis, % (n)** | |
| **Stroke** | 40.1% (4,392) |
| **Motor neurone disease** | 7.2% (788) |
| **Parkinson's disease** | 5.4% (591) |
| **Multiple sclerosis** | 4.9% (537) |
| **Dementia** | 7.2% (788) |
| **Other** | 35.2% (3,855) |
| **Any non-cancer co-morbidity, % (n)** | |
| **Absent** | 68.4% (7,491) |
| **Present** | 31.6% (3,461) |
| **Died within 7 days of PEG insertion, % (n)** | 4.2% (459) |
| **Died within 30 days of PEG insertion, % (n)** | 14.6% (1,598) |

The crude all-cause mortality rate at 7 and 30 days was 4.2% and 14.6% respectively. Univariate analysis (Table 4.6) confirmed emergency admission and increasing age as risk factors for mortality at both 7 and 30 days ($p$<0.001). The presence of a code for co-morbidity, stroke or dementia was also significantly associated with mortality at 7 and 30 days ($p$<0.001). Longer term all-cause mortality was 27.5% at 3 months and 35.5% at 6 months. At one year mortality was 44.3%.

Binary logistic regression identified age, male sex, emergency admission, motor neurone disease and dementia as predictors of 30-day death. Details are described in Table 4.7.

**Table 4.6 Factors associated with all-cause mortality following PEG insertion. Univariate analysis for procedures performed 2006-2008.**
**(n=10,952)**

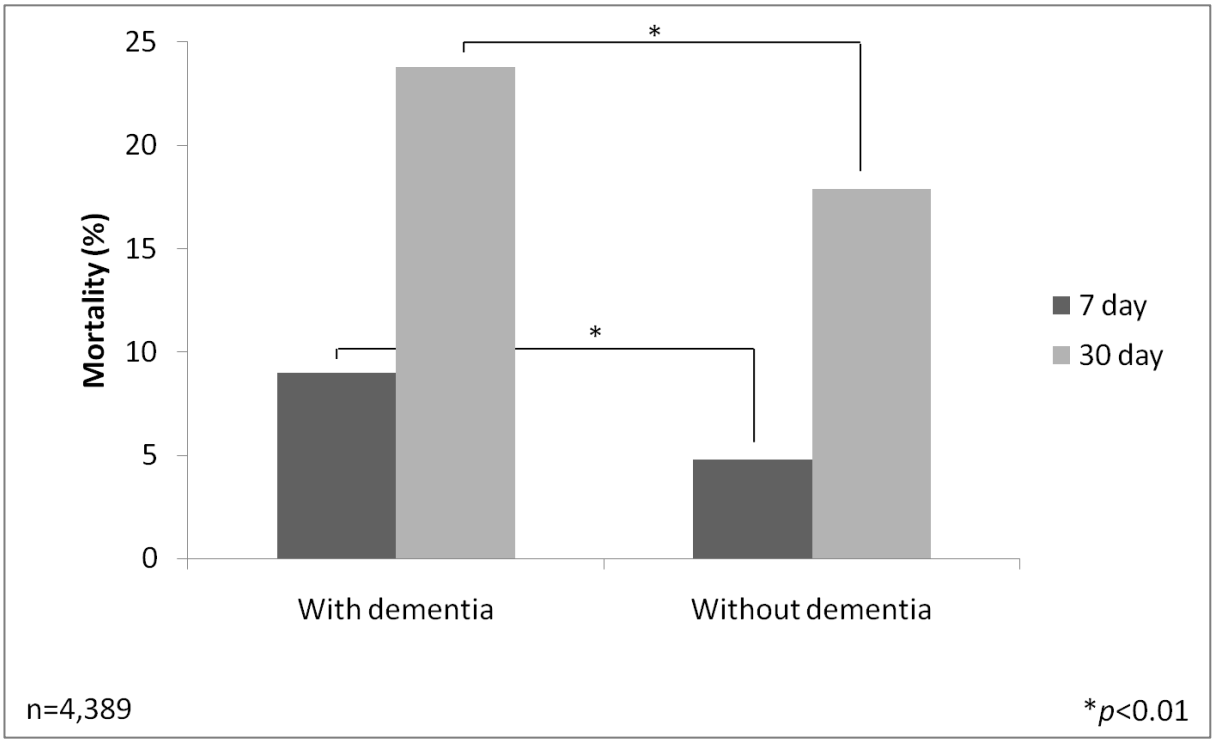
| Variable | 30-day all-cause mortality | 7-day all-cause mortality | *p* |
|---|---|---|---|
| **Admission** | | | |
| **Elective** | 6.8% | 1.7% | |
| | | | ***p*<0.001** |
| **Non-elective (emergency)** | 17.6% | 5.1% | |
| **Age** | | | |
| **< 55 years old** | 4.0% | 1.2% | |
| **55-64** | 9.6% | 2.4% | |
| **65-74** | 13.6% | 4.1% | |
| **75-84** | 18.3% | 5.1% | |
| **>84 years old** | 25.6% | 7.3% | ***p*<0.001** |
| **Co-morbidity** | | | |
| **Absent** | 11.6% | 3.0% | |
| | | | ***p*<0.001** |
| **Present** | 21.1% | 6.6% | |
| **Stroke diagnosis** | | | |
| **Absent** | 12.1% | 3.5% | |
| | | | ***p*<0.001** |
| **Present** | 18.3% | 5.1% | |
| **Dementia diagnosis** | | | |
| **Absent** | 14.0% | 3.8% | |
| | | | ***p*<0.001** |
| **Present** | 22.1% | 8.7% | |

**Table 4.7 Factors associated with all-cause mortality within 30 days of PEG insertion: Binary logistic regression analysis of procedures performed in England 2006-2008. (n=10,952 patients). Odds ratios with 95% confidence intervals.**

| Independent variable | Odds ratio | 95% CI | *p* |
|---|---|---|---|
| **Age Group** | | | |
| **<55 years** | 1 | - | |
| **55-64 years** | 2.4 | 1.9-3.2 | |
| **65-74 years** | 3.3 | 2.6-4.2 | |
| **75-84 years** | 4.5 | 3.5-5.7 | |
| **>84 years** | 6.8 | 5.3-8.7 | ***p*<0.03** |
| **Sex** | | | |
| **Female** | 1 | - | |
| **Male** | 1.3 | 1.1-1.4 | ***p*<0.03** |
| **Admission type** | | | |
| **Elective** | 1 | - | |
| **Non-elective (emergency)** | 2.2 | 1.9-2.6 | ***p*<0.03** |
| **Motor Neurone Disease** | | | |
| **Absent** | 1 | - | |
| **Present** | 1.3 | 1.1-1.7 | ***p*<0.03** |
| **Dementia** | | | |
| **Absent** | 1 | - | |
| **Present** | 1.2 | 1.0-1.5 | ***p*<0.03** |

In older patients (≥85 years old) having a PEG insertion during emergency admission, dementia was associated with 7-day mortality of 14.6% compared to 7.8% in stroke. In patients with PEG insertion and a stroke diagnosis code (n=4,389) there was a significant increase in mortality at 7 and 30 days for those with dementia compared to those without a code for dementia (Figure 4.1). At 7 days mortality was 9% in those with dementia compared to 4.8% in those without. At 30 days mortality was 23.8% with and 17.9% without dementia ($p$<0.01).

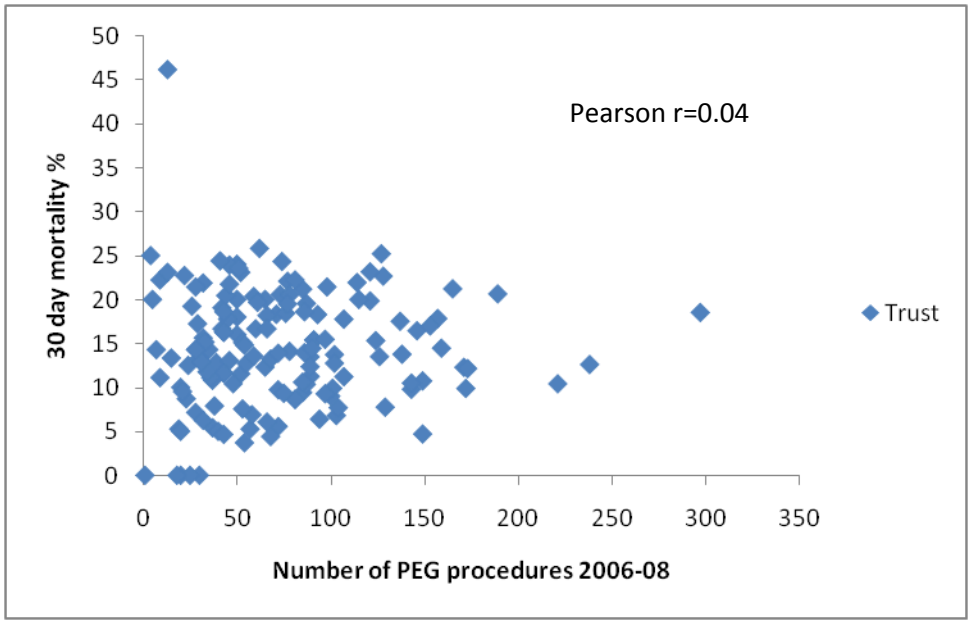
**Figure 4.1 All-cause mortality for stroke patients with and without dementia**




At Trust level no correlation was seen for all-cause 30-day death versus PEG volume (Figure 4.2). At strategic health authority level wide variation was seen in the rate of PEG insertions and also in the rate for different disease groups. Overall, for the 10 SHAs, the mean PEG insertion rate per 100,000 population was 21.6. Figures ranged

from 18.5 to 27 per 100,000 across the ten SHAs. The proportion of insertions performed in patients with a dementia diagnosis ranged from 4.1% to 10.3% (6.8% overall), whilst the proportion performed in patients with a stroke diagnosis ranged from 23.1% to 46.6% (40% overall).

**Figure 4.2 All-cause 30 day mortality against volume of PEG procedures performed in each Trust over 2006-2008**




## A bedside tool for predicting mortality risk after PEG

Look-up tables were created for predicting outcomes (Tables 4.8 & 4.9) from the target population of 10,952 patients with PEG insertion coded with the G445 OPCS code. The denominator population was zero in some categories but a trend of increasing mortality with additional risk factors can be seen. This was the case for mortality within 7 and 30 days of PEG procedure.

**Table 4.8 All-cause mortality within 7 days of PEG according to age group, admission method (elective or emergency) and presence of co-morbid conditions**
**Pooled data for 2006/07 and 2007/08 for acute hospital Trusts in England (n= 10,952)**

| Emergency | Dementia | Stroke | <55 years old | 85+ |
|---|---|---|---|---|
| No | No | No | 0.8% | 2.8% |
| No | No | Yes | 2.6% | 4.8% |
| No | Yes | No | 0% (n=10) | 9.1% |
| No | Yes | Yes | N/A (n=0) | 14.3% |
| Yes | No | No | 1.3% | 6.1% |
| Yes | No | Yes | 1.2% | 6.9% |
| Yes | Yes | No | 17.6% | 13.6% |
| Yes | Yes | Yes | 0% (n=2) | 15.4% |

**Table 4.9 All-cause mortality within 30 days of PEG according to age group, admission method (elective or emergency) and presence of co-morbid conditions**
**Pooled data for 2006/07 and 2007/08 for acute hospital Trusts in England (n= 10,952)**

| Emergency | Dementia | Stroke | <55 years old | 85+ |
|---|---|---|---|---|
| No | No | No | 2.4% | 12.8% |
| No | No | Yes | 6.4% | 22.2% |
| No | Yes | No | 0% (n=10) | 27.3% |
| No | Yes | Yes | N/A (n=0) | 14.3% |
| Yes | No | No | 4.9% | 26.8% |
| Yes | No | Yes | 4.2% | 25.3% |
| Yes | Yes | No | 23.5% | 35.0% |
| Yes | Yes | Yes | 0% (n=2) | 32.5% |

## Discussion

These national-level linkage analyses provide real-world estimates of prognosis in subjects selected for PEG in England and identify factors associated with all-cause death. Elderly subjects with dementia are a particularly high-risk group and present an ethical dilemma for PEG placement. This is the largest-scale UK-based study available for all-cause mortality after PEG.

Results generated in this study are in keeping with previous studies. The 30-day mortality rate is perhaps better than expected from previous literature but may be explained by the exclusion of cancer patients.

The raw data on which our analysis is based is routinely collected and therefore systematic bias is avoided. The number of PEG insertions captured for our own Trust was in keeping with local audit figures and we believe generally capture was good. Linkage of data to ONS mortality data ensures accurate mortality figures and allows full assessment of 30-day mortality but also longer term mortality rates which is particularly useful for PEG outcomes analysis. Few studies have been able to provide robust data on survival beyond one month of PEG insertion.

Currently gastrostomy insertion can be coded with codes other than the most specific G445 code. NCEPOD reported 16,648 PEG procedures being performed in England in 2002/03 with an overall 30-day mortality of 6%[52]. They extracted these figures from HES data for that financial year using OPCS codes G34. The G445 code, which is specific for endoscopic placement of gastrostomy tube, was only introduced in 2006/07. The G34 group is shown in Table 4.8[140].

**Table 4.10 OPCS code descriptions**

| OPCS Code | Description | |
|---|---|---|
| **G34.1** | Artificial opening into stomach, | Creation of permanent gastrostomy |
| **G34.2** | Artificial opening into stomach, | Creation of temporary gastrostomy |
| **G34.3** | Artificial opening into stomach, | Reconstruction of gastrostomy |
| **G34.4** | Artificial opening into stomach, | Closure of gastrostomy |
| **G34.5** | Artificial opening into stomach, | Attention to gastrostomy tube |
| **G34.8** | Artificial opening into stomach, | Other specified |
| **G34.9** | Artificial opening into stomach, | Unspecified |

Thus, NCEPOD data may have included patients with a PEG already in-situ and not those undergoing PEG insertion. This would potentially dilute the mortality rate and account for their lower mortality estimate of 6%.

The NCEPOD report looked at 719 deaths within 30 days of a PEG procedure. 17.75% (126) had a coded malignancy; 19.44% (138) had dementia, 82.54% (586) had a neurological condition coded and 42.25% (300) had nutritional failure due to non-malignant disease. The groups were not mutually exclusive and were the groups specified in the retrospective questionnaire sent to endoscopists. ICD codes were not specified.

Limitations of this study include concerns regarding the accuracy of HES data. With particular reference to the PEG datasets the introduction of the G445 code should improve coding compared to previously where a number of codes were used in more than one combination to identify a procedure. It is not possible to ascertain the primary indication for the PEG procedure form HES data. This can only be inferred from the diagnoses included in the PEG episode. Our decision to exclude cancer cases may be a limitation in that as well as excluding those patients with head and neck cancer having peri-operative or peri- radiotherapy PEG insertions

(our intention) we may have also excluded many patients with other indications for PEG insertion who had a cancer coded that was not necessarily the primary illness at the time of PEG insertion e.g. patients with a code for prostate cancer. However, we believe that this exclusion would strengthen our results rather than weaken them.

Analysis of diagnostic codes and attempts to categorise patients was hampered by the wide number of diagnostic codes used. A significant number of patients could not be assigned to a particular diagnostic group for further analysis. This issue has been highlighted elsewhere[221]. Solutions include encouraging clinicians to document specific diagnoses rather than symptoms and engagement of clinicians in the use of coded administrative data.

As in the ERCP study the rate of coding for co-morbid conditions was very low and limited the ability to adjust for case-mix. This echoed the problem with trying to define the indication for PEG and identifying specific causes of death.

PEGs are inserted to improve or maintain quality of life in those who are unable to take adequate nutrition by other means. Specific quality of life outcomes were not analysed in this study. Potential measures within HES include discharge destination and readmission rates. However, measuring quality of life as opposed to quantity will require some form of patient reported outcomes which are currently not available within HES.

The general trend of increasing mortality with additional risk factors, illustrated by the look-up tables, is not unexpected. The inconsistent results are probably due to the small numbers of patients in those categories.

## Further work

This chapter has provided data on overall outcomes for patients having PEG insertion. Administrative data can be used to assess the impact of PEG insertion on outcomes for particular groups of patients in the long term (see Stroke chapter). PEG insertion is an invasive procedure with potentially significant risks. Providing more long term survival and quality of life data such as discharge destination and readmissions for particular patient groups who have had PEGs, e.g. stroke patients, will aid clinicians in their decision making and guide their discussions with patients and their families.

# 5. Stroke

# 5. Stroke


## Abstract

***Background and aims*:** Stroke affects between 174 and 216 people per 100,000 people in the UK each year. Swallowing can be affected in up to 40% of stroke patients, with 30% having evidence of poor nutrition, malnutrition and dehydration after their stroke. The aim of gastrostomy insertion (PEG) is to allow those without a safe swallow to maintain adequate nutrition. However, PEG insertion is not without risk and the overall impact of gastrostomy insertion on outcome in stroke patients is unclear. There is a lack of good evidence to assist in making decisions regarding PEG insertion in stroke.

The aim of this study is to show that HES data can be used to describe the stroke population in England; assess patterns of PEG insertion in stroke patients and identify the factors that affect outcome in this specific group of patients. Specifically, we want to assess whether early mortality after PEG procedure in acute stroke is lower in those units performing a larger volume of PEG procedures and whether this measure has potential as a clinical indicator for care quality.

***Methods:*** Episodes of care containing ICD-10 diagnosis codes for stroke were extracted from the HES datasets. OPCS-4 codes for PEG procedures were identified within these episodes.

Inclusion criteria for the denominator stroke population were a new diagnosis of stroke, emergency admission and length of stay greater than 7 days. Final analysis was restricted to those cases with a PEG procedure during their index admission, occurring at least 8 days after admission. Variables for mortality within 7, 30, 90

and 180 days were added using data from the Office of National Statistics death registry. Cases were analysed for stroke type, co-morbidity, deprivation, age and gender. Trusts were classified by stroke case volume and by total PEG procedure volume to assess for effect on survival. Factors associated with mortality were identified by univariate and multivariate analyses.

***Results*:** Of 87,507 new stroke admissions in 12 months, there were 42,550 stroke cases meeting our inclusion criteria. This included cases from 137 out of 151 Trusts in England. A total of 1560 eligible PEG cases were identified.

Within our denominator population of strokes (n=42,550) the proportion of eligible stroke patients having a PEG procedure in their index stroke admission ranged from 0.8% to 15.1% at each Trust. Compared to stroke patients in general, those requiring gastrostomy insertion during their index admission stayed longer in hospital (mean stay 65 days vs. 29 days), were less likely to be discharged to their own home (25% vs. 53%), and had higher mortality at 6 months (46% vs. 31%). They were slightly older (mean age 79 years vs. 78 years) and were more likely to have suffered a haemorrhagic stroke (13% vs. 10%).

The presence of co-morbid conditions was independently associated with higher mortality after gastrostomy insertion with an odds ratio of 2.040 (CI 1.269-3.278, p=0.003) for 7-day mortality compared to those without a co-morbid condition coded. Older age was not associated with any increased risk of mortality. Admission to Trusts with a high PEG procedure volume was associated with lower 7-day mortality after PEG procedure of 4.3%, compared to 7.8% and 6.8% in low and medium volume Trusts respectively (p=0.045). Adjusted odds ratio for 7-day

mortality after PEG in low volume Trusts, compared to high volume Trusts was 1.842 (CI 1.065-3.189, p=0.029).

***Conclusions*:** Early mortality after PEG procedure in stroke patients is a potential indicator for the quality of care received by such patients. Differences in 7-day post-procedure mortality may reflect variation in case selection, technical ability and medical care around the time of a PEG procedure.

## Introduction

The aims of this chapter are to assess outcomes for stroke patients using HES data. It continues work from the previous chapter and looks at the impact of PEG insertion on outcomes in stroke. Specifically, the aims are:

1. To generate national and hospital-level measures of process (length of stay) and outcome (all-cause mortality) for patients admitted to NHS hospitals with a first acute stroke using a two-year download of Hospital Episode Statistics (2006/07 and 2007/08);
2. To identify a sub-population of emergency stroke admissions requiring placement of percutaneous gastroscopy (PEG), based on coded procedures and describe their characteristics;
3. To test a specific hypothesis about the volume-outcome relationship across English hospitals. Specifically, to test the hypothesis that those institutions performing the highest annual volume of PEG procedures are likely to have the lowest rates of short-term mortality after PEG placement in acute stroke (reflecting greater experience and expertise in patient selection, peri-procedure care and safety in relation to the PEG procedure).

### *Background*

Stroke has been defined by the World Health Organisation[196] as a 'clinical syndrome, of presumed vascular origin, typified by rapidly developing signs of focal or global disturbance of cerebral functions lasting more than 24 hours or leading to death.'

Stroke affects between 174 and 216 people per 100,000 people in the UK each year. Stroke accounts for 11% of all deaths in England and Wales. 69% of strokes are due to cerebral infarction[196]. The Stroke Association states that about a third of those having a stroke will die within 10 days. The Framingham Study[222] showed an overall 30-day mortality of 28%, with rates for ischaemic stroke of 19% at 30 days and 23% at 1 year.

Guidelines published by NICE and the Royal College of Physicians in 2008[196;223] state that swallowing can be affected in up to 40% of stroke patients with 30% having evidence of poor nutrition, malnutrition and dehydration after their stroke. All these factors are associated with worse outcome. These guidelines recommend that gastrostomy feeding should be considered for the following stroke patients:

- Those who are unable to tolerate naso-gastric feeding within the first four weeks;
- Those unable to maintain adequate oral intake at 4 weeks;
- Those who are at long-term, high risk of malnutrition.

An American study found that 11.6% (77/664) of stroke patients with dysphagia required gastrostomy tube insertion[224]. In one study of 187 patients, 17.6% had PEG insertion during their stroke admission. These patients were older, had more severe strokes (defined using the National Institute of Health Stroke Scale; NIHSS[225]) and a longer length of stay when compared to those patients not requiring PEG insertion. Independent predictors for PEG insertion were bulbar symptoms at onset, higher NIHSS score, stroke in the middle cerebral artery territory, and aspiration pneumonia[226]. Stroke was the indication for 40.7% of PEG insertions in another study looking at PEG insertions in the elderly population[227]. This was followed by

neurodegenerative conditions (34.7%) and cancer (13.3%). Overall mortality for all PEG insertions was 22% at 30 days and 50% at one year. This is consistent with other data reporting mortality rates at 1, 6, and 12 months of approximately 20%, 40% and 50%. Lower 30-day mortality rates e.g. 10.7% have been described[228]. One year mortality rates as high as 90% have been reported in patients with dementia[216]. The use of NIHSS scores to predict PEG insertion is supported by results from a retrospective study of 77 patients with acute stroke and severe dysphagia, 20 of whom required PEG insertion[229]. Patients in this study were identified using ICD codes for acute ischaemic stroke, OPCS codes for gastrostomy and specific coding indicating formal speech and language swallow assessment. An in-hospital mortality of 28% was recorded in a Welsh study of stroke patients requiring PEG insertion[230].

A German paper used a national database of geriatric patients to explore PEG insertion rates and outcomes[231]. They suggested that 140,000 PEG insertions occur each year in Germany, 65% of which are in patients over the age of 65 years. Their database analysis of 27,775 geriatric patients found a PEG insertion rate of 1.4%. Two-thirds of these were in stroke patients and PEG patients tended to have poorer Barthel Index scores[232]. In-hospital mortality was 17.6% in PEG patients, compared to 4.3% in those patients not requiring PEG insertion.

The British Artificial Nutrition Survey (BANS) reports annually on nutrition support in the UK (all indications). It found a prevalence of enteral tube feeding in the community of 21,858 people in 2007[221]. The vast majority were being fed via gastrostomy (18,075, 82.7%). Over half were in their own home but 31.2% were in

nursing homes. Of those in nursing homes 93% were fed via gastrostomy. The main diagnostic categories for patients were central nervous system disorders and mental health (50% - nearly half of whom have a stroke diagnosis); cancer (36%); non-malignant gastrointestinal diagnoses (8%) and other conditions (6%).

PEG insertion has been widely used for many years. However, it is becoming recognised that PEG insertion may not improve long term outcomes for certain groups of patients[227]. For example, there is compelling evidence that PEG insertion in patients with significant dementia increases mortality[216;233]. Requiring PEG insertion has been shown as marker for poor long term outcome in stroke patients[234;235]. There has been controversy surrounding the timing of PEG insertions in patients with acute stroke and evidence of wide variation between hospitals[236]. Gastroenterologists will often be asked to insert gastrostomy tubes in stroke patients early in the course of the illness and often in an emergency or urgent basis. There is little good evidence to assist in making these decisions and the few studies that exist show conflicting results. The 'Feed Or Ordinary Diet' (FOOD) project enrolled over five thousand patients with recent stroke between 1996 and 2003[218]. One of the three RCTs within the FOOD project looked at PEG vs. NG feeding in dysphagic stroke patients. Patients were allocated to PEG or NG within 30 days of admission. Numbers were small and the populations heterogeneous with 321 patients across 47 hospitals in 11 countries. They concluded that initiation of PEG feeding following acute stroke was associated with poorer functional outcome and increased mortality. However, their findings were not statistically significant with PEG insertion associated with an increase in absolute risk of death of 1.0% (95% CI -

10.0 to 11.9; p = 0.9) and an increased risk of death or poor outcome of 7.8% (95% CI 0.0 to 15.5; p = 0.05).

The FOOD trial did not support the early initiation of PEG feeding in stroke patients. Other authors have suggested a 'cooling off' period before PEG insertion [237-239] [208]. One of the few randomised trials to look at naso-gastric versus PEG feeding concluded that PEG at 14 days post acute stroke was superior to naso-gastric feeding. It was a small study of thirty patients with acute dysphagic stroke who were randomised to either naso-gastric feeding or PEG insertion. Outcomes at 6 weeks were significantly better in the PEG group including mortality, length of stay and nutritional intake[217].

A Cochrane review of stroke literature in 2000 concluded that there was some evidence supporting PEG insertion in stroke patients improving outcomes but that overall there were too few studies, consisting of too few patients[240]. A further literature review published in 2008 again commented on the paucity of robust trial data[233].

Hospital episodes statistics provide data on a large number of patients including those patients with strokes. I aim to show that HES data can be used to provide robust analysis to assist in decision making surrounding PEG insertion following stroke and assess the effect of PEG insertion on long term outcomes.

*(Please see the introduction of the PEG chapter for more background information on PEG insertions.)*

## Methods

From our master files for 2006/07 and 2007/08 (*see ERCP Method section: The Master Datasets*), episodes of care containing ICD-10 diagnosis codes for stroke were extracted. OPCS-4 codes for PEG procedures were identified within these episodes.

Deaths within 7, 30 and 180 days were identified. Diagnostic fields were analysed for diagnoses and co-morbidity. PEG and stroke volume were assessed at Trust and national level. Place of discharge was identified for all episodes. Factors associated with death were identified by univariate and multiple logistic analyses.

## The Stroke Datasets

From the Master Datasets described in the ERCP chapter method section we extracted episodes containing an ICD-10 stroke code in diagnostic code positions 1 and/or 2. These episodes were then saved as two new stroke datasets, one for each data year. Appendix 7.1 contains the syntax used to extract these episodes. The full list of stroke codes used in this analysis is found in Table 5.1.

**Table 5.1 ICD-10 codes for stroke used in study**

| ICD-10 Code | Description |
|---|---|
| G450 | Vertebro-basilar artery syndrome |
| G451 | Carotid artery syndrome (hemispheric) |
| G460 | Middle cerebral artery syndrome |
| G461 | Anterior cerebral artery syndrome |
| G462 | Posterior cerebral artery syndrome |
| G463 | Brain stem stroke syndrome |
| G464 | Cerebellar stroke syndrome |
| G465 | Pure motor lacunar syndrome |
| G467 | Other lacunar syndromes |
| G468 | Other vascular syndromes of brain in cerebrovascular disease |
| G810 | Flaccid hemiplegia |
| G811 | Spastic hemiplegia |
| G819 | Hemiplegia, unspecified |

| | |
|---|---|
| I610 | Intracerebral haemorrhage in hemisphere, subcortical |
| I611 | Intracerebral haemorrhage in hemisphere, cortical |
| I612 | Intracerebral haemorrhage in hemisphere, unspecified |
| I613 | Intracerebral haemorrhage in brain stem |
| I614 | Intracerebral haemorrhage in cerebellum |
| I615 | Intracerebral haemorrhage, intraventricular |
| I616 | Intracerebral haemorrhage, multiple localized |
| I618 | Other intracerebral haemorrhage |
| I619 | Intracerebral haemorrhage, unspecified |
| I629 | Intracranial haemorrhage (nontraumatic), unspecified |
| I630 | Cerebral infarct due to thrombosis of precerebral arteries |
| I631 | Cerebral infarction due to embolism of precerebral arteries |
| I632 | Cerebral infarct due unspecified occlusion or stenosis precerebral arteries |
| I633 | Cerebral infarction due to thrombosis of cerebral arteries |
| I634 | Cerebral infarction due to embolism of cerebral arteries |
| I635 | Cerebral infarct due unspecified occlusion or stenos cerebral arteries |
| I636 | Cerebral infarct due cerebral venous thrombosis, nonpyogenic |
| I638 | Other cerebral infarction |
| I639 | Cerebral infarction, unspecified |
| I64X | Stroke, not specified as haemorrhage or infarction |
| I650 | Occlusion and stenosis of vertebral artery |
| I651 | Occlusion and stenosis of basilar artery |
| I652 | Occlusion and stenosis of carotid artery |
| I653 | Occlusion and stenosis of multiple and bilateral precerebral arteries |
| I658 | Occlusion and stenosis of other precerebral artery |
| I659 | Occlusion and stenosis of unspecified precerebral artery |
| I660 | Occlusion and stenosis of middle cerebral artery |
| I661 | Occlusion and stenosis of anterior cerebral artery |
| I662 | Occlusion and stenosis of posterior cerebral artery |
| I663 | Occlusion and stenosis of cerebellar arteries |
| I664 | Occlusion and stenosis of multiple and bilateral cerebral arteries |
| I668 | Occlusion and stenosis of other cerebral artery |
| I669 | Occlusion and stenosis of unspecified cerebral artery |
| I670 | Dissection of cerebral arteries, nonruptured |
| I672 | Cerebral atherosclerosis |
| I678 | Other specified cerebrovascular diseases |
| I679 | Cerebrovascular disease, unspecified |
| I688 | Other cerebrovascular disorders in diseases EC |
| I691 | Sequelae of intracerebral haemorrhage |
| I692 | Sequelae of other nontraumatic intracranial haemorrhage |
| I693 | Sequelae of cerebral infarction |
| I694 | Sequelae of stroke, not specified as haemorrhage or infarction |

### *Achieving a 12-month cohort of new strokes*

In order to capture new strokes and achieve 12-month mortality data for all cases we selected cases *without* stroke codes evident in the first 6 months of our two year period and excluded cases with a new stroke diagnosis in the last 6 months of our dataset. Only cases coded in position 1 or 2 were included as we wished to capture acute strokes rather than longstanding diagnoses. Code counts for each of the ICD code positions revealed that the number of codes for stroke was much lower but more stable from position 3 onwards, compared to the first two code positions. This is consistent with the primary admission diagnosis being coded in the first two positions and the remaining positions being utilised to describe co-morbid or pre-existing disease.

Before merging the two stroke datasets two variables were added to each dataset. These were 'YEAR', to indicate which financial year the episode occurred; and 'MONTHTAG' to indicate in which month the episode ended. The two datasets were then merged using the 'Merge data; Add cases' function in SPSS. The 'MONTHTAG' variable then allowed us to extract the middle 12 months of data (months 7-18) to create our final Stroke dataset.

### *Deletions and identifying duplicates*

Patients within the 12-month cohort, with an episode length of stay over 6 months were deleted in order to exclude those admitted with a stroke prior to the start of our study period. All related data for patients identified by these episodes were deleted. The dataset was reduced further by selecting only completed admissions (identified by the binary variable 'SPELLEND'= Y within SPSS). Data for patients with

a PEG date before their stroke admission were also deleted as this would suggest they had a pre-existing reason for their PEG (See below for methodology).

Duplicate entries were removed by first sorting the data by the NEWHESID, ADMIDATE, DIAG 01, DIAG 02 and PROC 1 variables; then searching for duplicates by NEWHESID and ADMIDATE using the 'Identify duplicates' function in SPSS. To get the first admission for every patient, data were sorted by NEWHESID and EPIORDER variables then the 'primary first' episode selected into our final dataset using the 'Identifying duplicates' function.

### *Identifying PEG procedures*

This procedure is described in both the ERCP and PEG chapter method sections.

Going back to our original master datasets all PEG procedures were identified for those patients contained within our final stroke dataset using their unique patient identifiers (HESID or NEWHESID). An interim dataset was created containing a row of data for each PEG code identified. A 'PEGDATE' variable was added, derived from the procedure dates (1-14). The interim dataset was ordered by HESID/NEWHESID and PEGDATE and the first occurring procedure copied into a new dataset. This data could then be merged with our final stroke dataset as the PEGDATE variable.

## Additional Variables

Please see the ERCP and PEG chapters for details of the HES variables and generic additional variables. New variables specific to the stroke dataset are described here and in Table 5.2.

**Table 5.2 Additional variables added to create final Stroke dataset**

| Variable | Description |
|---|---|
| **HOWMANYDAYSAFTERADMWASFIRSTPEG** | Number of days from admission to PEG procedure calculated using the 'date and time wizard' function in SPSS |
| **PEGINFIRSTSTROKEADM** | 1=PEG procedure occurred in stroke admission; 2=No PEG or PEG procedure occurred in subsequent admission. **See Appendix 7.1 - Stroke Syntax 18** |
| **ALIVEDEAD30DAYAFTERPEG** | 1 = died within 30 days; 2 = died after 30 days of PEG; 3 = did not die. **See Appendix 7.1 - Stroke Syntax 19.** Can be modified to give 7-day marker. |
| **IMDQUINTILE** | Deprivation quintile 1-5 with 1 the most deprived. See Deprivation scores section |
| **READMIT 7 & READMIT 30** | 1= Readmission within 7 or 30 days of stroke discharge<br><br>**See Appendix 7.1 - Stroke Syntax 23** |
| **DISCHNURSINGHOME** | 1=Discharged to Nursing home following stroke admission<br><br>**See Appendix 7.1 - Stroke Syntax 22** |
| **DIED7DAYS; DIED30DAYS; DIED90DAYS; DIED180DAYS** | 1=Death within 7, 30, 90 or 180 days of stroke admission. **See Appendix 7.1 - Stroke Syntax 8** |
| **PEGDEATH7 AND 30** | 1=Death within 7 or 30 days of PEG procedure date |

| | |
|---|---|
| **LOWPEGVOLTRUST; MEDVOLPEGTRUST; HIGHVOLPEGTRUST** | 1 denotes which tertile the treating Trust belongs to according to the total number of PEG procedures performed over the 2 year study period for all indications. Totals were taken from the PEG datasets used in the last chapter. **See Appendix 7.1 – Stroke Syntax 25** |
| **LOWSTROKEVOL; MEDSTROKEVOL; HIGHSTROKEVOL** | The total number of strokes admitted to each selected Trust over the 2 year study period was extracted from our original stroke dataset. Trusts were divided into tertiles according to their total. **See Appendix 7.1 – Stroke Syntax 26** |
| **SINAPTERTILE1, SINAPTERTILE2, SINAPTERTILE3** | The average of 9 domain scores was calculated for each Trust. Trusts were then categorised according to their score with SINAPTERTILE1 having the lowest scores. **See Appendix 7.1 – Stroke Syntax 27** |

### *Deprivation Scores*

Deprivation is measured for geographical areas called super output areas (SOA). Scores are calculated within seven domains which are listed below. Each domain contains a number of indicators and the weighting of each domain is given in brackets.

- Income (22.5%)
- Employment (22.5%)
- Health Deprivation and Disability (13.5%)
- Education, Skills and Training (13.5%)
- Barriers to Housing and Services (9.3%)

- Crime (9.3%)
- Living Environment (9.3%)

The domain scores are combined, according to the weighting, to give the Index of Multiple Deprivation (IMD) score. A score of 1 is the most deprived, 32,482 the least deprived area[241]. The super output areas are then ranked according to their score and divided into quintiles, with quintile 1 the most deprived areas and 5 the least deprived.

The HES data provided to us by Northgate contains a variable 'IMD04RK'. This is the overall rank of the IMD scores for the super output area (SOA) in which the patient lives (Note: Not where they are being treated). By organising the dataset in ascending order of IMD04RK the corresponding national quintile level could then be merged and assigned to our datasets.

### *Readmission markers*

Readmissions were identified by first saving the HESID of all patients in our final stroke dataset into an interim dataset. Using the original datasets and this HESID dataset all emergency admissions within the two year study period were identified for these HESID and saved as the interim dataset. The stroke admission date for each of these patients was then added to the interim dataset. Using the Date and Time Wizard in SPSS the number of days between each emergency admission and the stroke admission was calculated. Emergency admissions occurring before the stroke admission were deleted. Following this, using the 'identify duplicates' function with sequential numbering, the next emergency admission following the stroke admission could be identified. The admission dates for these episodes were

saved and merged onto our final stroke dataset. Markers for readmission within 7 and 30 days of discharge from the stroke admission could then be calculated.

### *PEG and Stroke volume Tertiles*

Using the original PEG datasets (Chapter 3), Trusts were categorized into High, Medium and Low volume Trusts for PEG procedures. This was based on the total number of PEG procedures for all indications, not just in stroke patients, for both years. A similar procedure was performed to produce markers for stroke volume tertiles. The total number of strokes, admitted to each Trust over the two year period, was extracted from our original stroke dataset. Our selected Trusts were then divided into tertiles according to the total number of stroke admissions.

### *National stroke audit performance*

SINAP is a national audit run by the Royal College of Physicians[242]. It aims to monitor standards of stroke care in the first 72 hours of admission across England. The 2008 stroke audit assessed performance across 9 indicators of stroke care with a final score given for the proportion of all stroke patients that received all 9 indicators (bundle of care). All results were given as a percentage of eligible patients.

The 9 indicators were:

1. Screening for swallowing disorders within 24 hours of admission
2. Brain scan within 24 hours of stroke
3. Physiotherapist assessment within 72 hours of admission
4. Occupational therapy assessment within 4 working days of admission
5. Patient weighed during admission
6. Patient's mood assessed by discharge
7. Rehabilitation goals agreed by the multidisciplinary team

8. Aspirin or Clopidogrel given by 48 hours after stroke
9. Patients spent at least 90% of stay on a stroke unit

The Royal College of Physicians published data from the 2008 stroke audit[243] which included results for 132 of the 137 Trusts in our final analysis. Trusts were asked to provide data on a minimum of 20 and maximum of 60 consecutive patients admitted with stroke between April 1st 2008 and June 30th 2008. An audit proforma was completed for each patient. A 'Total Process Score' was derived from information on 26 standards, divided into 6 domains of care. An average of nine key process indicator scores was also calculated which was found to correlate well with the Total Process Score. It is this average score that I have used in the following analysis.

We assessed the scores in each domain and calculated the average score for each of the 132 Trusts we had SINAP data for (out of 137 of our selected Trusts). Trusts were then ranked and data assessed for correlation between stroke indicator performance and mortality following stroke and PEG insertion in stroke. Raw data are shown in Table A5.1 in Appendix 7.5.

## The Final Stroke Datasets

At this point we had a dataset containing data for all patients presenting with stroke during a 12-month period. The focus of this study was to assess outcomes for patients admitted with a significant acute stroke that required a PEG procedure as a result of dysphagia caused by the neurological insult. Thus, we decided to create a more selective dataset for further analysis. Inclusion criteria for the denominator stroke population were:

- Emergency admission
- First diagnosis of stroke
- Length of stay of more than 7 days

We then selected a sub-population of those cases having a PEG procedure according to the following criteria:

- PEG procedure during the index stroke admission
- PEG procedure at least 8 days after admission

These criteria were selected to try and eliminate atypical cases and reduce skewing of data. Stroke admissions of less than a week are likely to be catastrophic strokes with early death, non-disabling strokes, and miscoded readmissions with old strokes or potentially not strokes at all. PEG procedures within the first week of an acute stroke are very unusual and such cases are likely to be miscoded readmissions for PEG procedures following old stroke or PEG insertions for other indications.

### *Exclusions*

All stroke cases from Trusts that had fewer than 2 PEG cases meeting the above criteria were excluded from the datasets. Episodes following transfer of patients from other Trusts were also excluded. Linkage to the pre-transfer admission is possible, but complex and the numbers of such episodes were too small to make it practical. Cases with a length of stay greater than 6 months were excluded. This was because we could not be sure when they had their stroke, or if this was coding error. Genuine admissions this long represented a small number of the total but would cause significant skewing of certain results.

## Statistical analysis

The Hospital episode data were stored, manipulated and analysed using the SPSS statistical package (SPSS Inc., Chicago, USA). National-level analyses of factors associated with all-cause death and other outcome measures were identified by univariate analysis and multiple logistic regression models. Statistical significance was achieved with $p<0.05$.

## Results

The Master files for 2006/07 and 2007/08 contained 10,753,151 and 11,296,023 episodes of inpatient care, respectively. From these files a total of 390,905 episodes containing stroke diagnosis codes in positions 1 or 2 were extracted (Table 5.3).

The dataset was then reduced to contain only the middle 12 months of new stroke admissions. In the first 6 months, (April to September 2006), 96,344 episodes for 56,094 patients were deleted. The HESID for these patients were then used to delete a further 112,493 related episodes of care from our core 12 months of data. This left 278,935 episodes in the dataset. The same process was applied to remove strokes occurring in the last 6 months of data (October 2007 to March 2008) and all associated episodes of care form the core 12 months. This left 181,082 episodes in the main stroke dataset.

**Table 5.3 Number of stroke codes in ICD-10 code positions 1 and 2 for 2006/07 and 2007/08**

| Year | ICD code position 1 | ICD code position 2 | Number of episodes |
|---|---|---|---|
| **0607** | 158,277 | 52,536 | **193,039** |
| **0708** | 162,212 | 54,922 | **197,866** |
| **TOTAL** | 320,489 | 107,458 | **390,905** |

**The final column shows how many episodes contained a stroke code (an episode can contain a stroke code in position 1 and 2 but would only generate one row of data)**

Further deletions were made due to poor quality data (Table 5.4) leaving 96,221 stroke admissions for a 12-month period. The dataset was then reduced to the first admission for each patient (n=87,507). We then selected just those admitted as an emergency as it is this population of acute first stroke that we wished to study. In total there were 80,113 new, emergency stroke admissions between September 2006 and September 2007.

**Table 5.4 Summary of deletions made to create 12-month All Strokes dataset**

| Reasons for deletion |
|---|
| **Patient episode finished in first 6 months (Apr 06 - Sep 06)** |
| **Related episodes from first 6 month deletions** |
| **Episode had missing episode end date** |
| **Patient episode finished in last 6 months (Oct 07 - Mar 08)** |
| **Related episodes from last 6 month deletions** |
| **Episode end date set to 15.10.1582** |
| **Spell length of stay greater or equal to 183 days** |
| **Episode length of stay greater or equal to 183 days** |
| **Related episodes from length of stay deletions** |
| **Missing deprivation score** |
| **Duplicate entries** |

We then selected 45,409 cases with a length of stay of greater than 7 days. Following exclusion of transfers (n=60) and Trusts without enough eligible PEG cases the denominator stroke population was finalised at 42,550 cases. This included 1560 PEG cases.

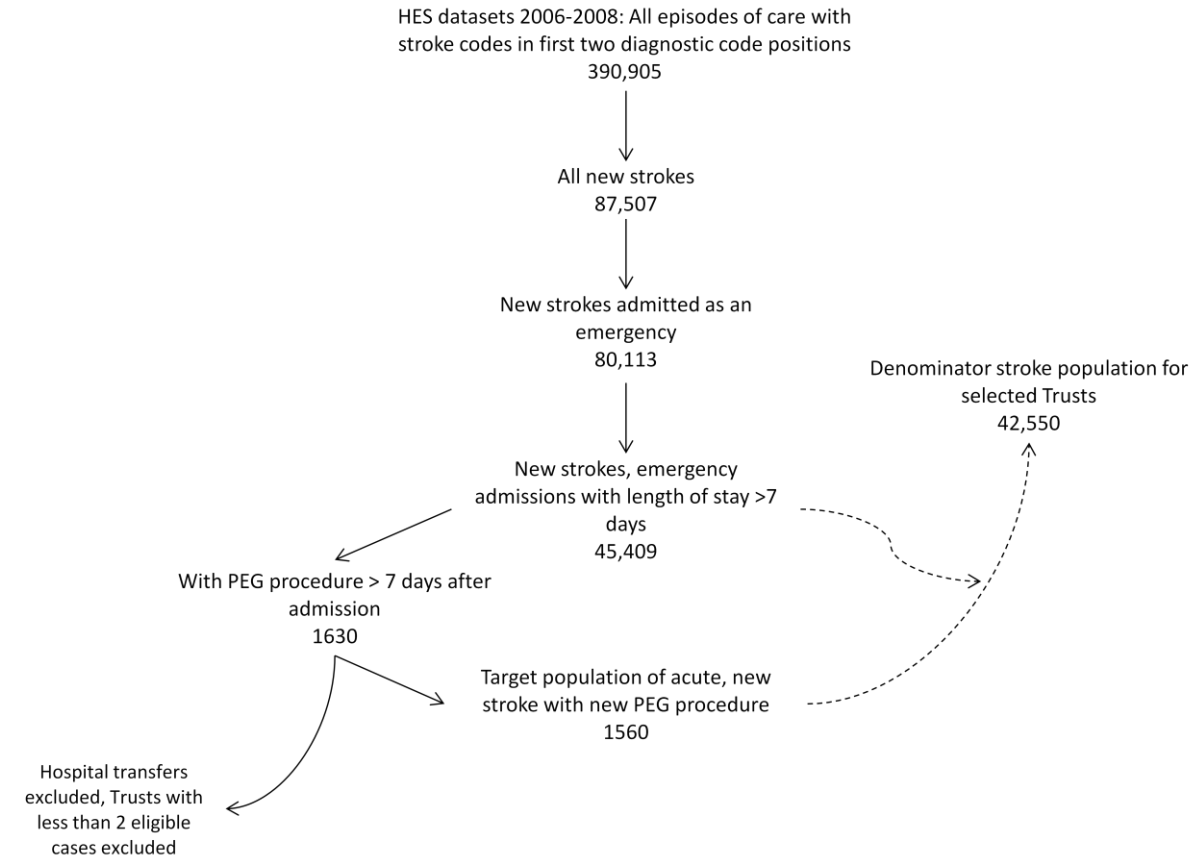



***Figure 5.1 Algorithm for stroke case selection***

## The Final Datasets

### *Denominator stroke population n=42,550*

The denominator population was defined as a new stroke diagnosis admitted as an emergency with an inpatient length of stay of greater than 7 days.

The mean age of these patients was 77.6 years (range 16-106, SD 12.323). Mean length of stay was just over 30 days, with a mode of 8 days and median stay of 20 days (range 8-182, SD 26.25). PEG procedures were performed in 1937 patients on average 42 days after admission (range 0-517, mode 19, and median 30, SD 48.262). Table 5.5 shows descriptive and outcome data for the denominator stroke population.

**Table 5.5: MASTER TABLE showing the patient characteristics and outcomes for selected stroke populations: i. Denominator stroke population of emergency admissions with new stroke with length of stay greater than 7 days; ii. Target population of stroke patients from the denominator population having a gastrostomy procedure more than 7 days after admission but before discharge; iii. Remaining stroke patients from the denominator stroke population who did not have a gastrostomy. (377 patients from the denominator population had gastrostomy procedures within the first 7 days of admission and were therefore outside our target population criteria. They were not included in further analysis.)**

| Variable | Denominator stroke population | Target stroke population with PEG | Stroke with no PEG | *p* (PEG vs. no PEG) |
|---|---|---|---|---|
| **Number of patients** | 42,550 | 1560 | 40,613 | - |
| **Male gender (n)** | 43.7% (18,587) | 46.7% (728) | 43.6% (17,700) | **0.05** |
| **Mean age in years (range, median, sd)** | 77.6 (16-106, 80, 12.323) | 79.2 (23-100, 81, 10.169) | 77.6 (16-106, 80, 12.391) | **<0.001†** |
| **Age groups (y)** | | | | |
| **<55** | 5.7% (2422) | 2.6% (40) | 5.8% (2355) | **<0.001** |
| **55 – 64** | 8.0% (3390) | 5.8% (90) | 8.1% (3270) | |
| **65 – 74** | 17.5% (7425) | 16.4% (256) | 17.5% (7090) | |
| **75 – 84** | 36.9% (15,700) | 42.4% (661) | 36.7% (14,893) | |
| **85 +** | 32.0% (13,613) | 32.9% (513) | 32.0% (13,005) | |
| **Co-morbidity** | | | | |
| **No co-morbidities** | 57.8% (24,578) | 56.3% (879) | 57.8% (23,479) | 0.25 |
| **One coded** | 26.8% (11,414) | 29.6% (462) | 26.7% (10,848) | |
| **More than one** | 15.4% (6558) | 14.0% (219) | 15.5% (6286) | |
| **Haemorrhagic stroke %** | 10.5% (4470) | 13.1% (204) | 10.3% (4196) | **<0.001** |
| **Dementia %** | 9.0% (3848) | 7.7% (120) | 9.1% (3701) | 0.06 |
| **Deprivation Quintiles** | | | | |
| **Most deprived** | 21.9% (9313) | 24.7% (386) | 21.7% (8829) | **0.005** |
| **2** | 21.4% (9105) | 21.8% (340) | 21.4% (8689) | |
| **3** | 20.6% (8778) | 19.4% (303) | 20.7% (8398) | |
| **4** | 19.6% (8331) | 17.9% (279) | 19.7% (7986) | |
| **Least deprived** | 16.5% (7009) | 16.1% (251) | 16.5% (6698) | |
| **Discharge destination (n)** | | | | |

| | | | | |
|---|---|---|---|---|
| **Own home** | 51.3% (21,822) | 24.6% (383) | 52.5% (21,304) | **<0.001** |
| **Nursing home** | 10.6% (4516) | 26.6% (415) | 10.0% (4042) | |
| **Other** | 17.0% (7236) | 22.4% (349) | 16.6% (6744) | |
| **Died in admission** | 21.1% (8976) | 26.5% (413) | 21.0% (8523) | |
| **Mean length of stay in days (range, median, sd)** | 30.25 (8-182, 20, 26.250) | 65.44 (9-178, 59, 33.030) | 28.8 (8-182, 20, 24.863) | **<0.001†** |
| **Number of days from admission to PEG procedure (range, sd)** | 42.5 (0-517, 48.262) n=1937 = ALL PEGs | 32.8 (8-148, 19.788) | na | - |
| **Emergency readmission (n)** | | | | |
| **7-day** | 3.8% (1635) | 4.0% (63) | 3.8% (1527) | 0.57 |
| **30-day** | 9.4% (3992) | 10.4% (163) | 9.2% (3731) | 0.09 |
| **Mortality from admission (n)** | | | | |
| **30-day** | 16.0% (6823) | 5.2% (81) | 16.6% (6727) | **<0.001** |
| **90-day** | 26.6% (11,333) | 32.2% (502) | 26.5% (10,764) | **<0.001** |
| **180-day** | 31.1% (13,236) | 46.0% (718) | 30.6% (12,412) | **<0.001** |
| **Mortality from PEG procedure (n)** | | | | |
| **7-day** | 0.2% (100) | 5.8% (91) | na | - |
| **30-day** | 0.9% (397) | 22.0% (343) | na | - |

†ANOVA. All others are $\chi 2$

Within the denominator stroke population the proportion of patients having a PEG procedure in their index stroke admission ranged from 0.8% to 15.1% across Trusts. Of the 137 Trusts included only 5 had a PEG insertion rate of 10% or more and 96 Trusts had a rate of below 5%. The 5 Trusts with the highest rate of PEG insertion had a mean 30-day mortality rate post PEG insertion of 3% compared to a mean rate of 0.9% in the remaining 132 Trusts. However, there did not appear to be any relationship between insertion rates and mortality at 7-days post PEG insertion or

at 30 days post admission with acute stroke. This may suggest that these Trusts were putting PEGs in stroke patients who were ultimately going to die of the stroke within 30 days anyway i.e. futile procedures but the comparable 7-day mortality figures after PEG insertion argues against this. No correlation was observed between insertion rates and total PEG procedure volume or stroke volume.

### *The Target PEG population n=1560*

The primary aim of this study was to assess outcomes in patients with acute, significant stroke who require a PEG procedure as a result of their stroke. By using our inclusion and exclusion criteria the risk of contaminating our final results with erroneous data from miscoding and atypical cases has been minimised. Table 5.5 shows descriptive data and outcome results for our selected PEG population.

The stroke population requiring a gastrostomy was compared to those stroke patients without a gastrostomy procedure. The target gastrostomy population had a higher proportion of men than the stroke population without gastrostomies: 46.7% compared to 43.6% ($p=0.05$). Patients without gastrostomy were younger: 77.6 years old compared to 79.2 years in the group with gastrostomy ($p<0.001$) and this was reflected in the spread of patients across the ten year age groups. Fewer than half of patients had a co-morbid condition coded with no significant difference between the two groups. The level of deprivation was similar in both groups except for the proportion from the most deprived areas. 24.7% of stroke patients having a gastrostomy were from the most deprived wards compared to only 21.7% in the stroke patients not requiring a gastrostomy ($p=0.005$). The proportion of patients with a code for haemorrhagic stroke was higher in the gastrostomy population (13.1% vs. 10.3%, $p<0.001$).

Mean length of stay was considerably longer in the PEG group (65.4 days vs. 28.8 days, $p<0.001$). This reflects the more severe and disabling strokes that will require alternative feeding methods. Readmission rates were similar for both groups. About 10% of patients were readmitted as an emergency within 30 days of discharge from their index stroke admission.

Overall mortality was 5.2% at 30 days post *admission* with acute stroke. This is much lower than that seen in the population without a gastrostomy (16.6%, $p<0.001$). By definition the patients in both datasets had to survive to 8 days of admission but for our selected PEG population they also had to survive to the point of PEG procedure. The mean time to PEG procedure was more than 42 days from admission. The higher mortality in the absent gastrostomy population represents patients clearly not suitable for PEG insertion due to frailty and poor prognosis that will have died within the first month of admission. There were marked differences in discharge destination between the two groups. Amongst those with a gastrostomy, discharge destination was fairly evenly split between own home (24.6%), nursing home (26.6%), other (22.4%) and dying during admission (26.5%). In the stroke population not requiring a gastrostomy over half the patients were discharged to their own home (52.5%) with only 10% going to nursing homes. Long term mortality was significantly higher in the gastrostomy group, rising to 46% at 6 months compared to 30.6% in the stroke group without gastrostomy. This is consistent with PEG insertion as a consequence of more severe strokes having excluded early catastrophic events. Mortality post PEG procedure was 5.8% and 22% at 7 and 30 days respectively.

## Factors associated with all-cause, early mortality, within 7 days of gastrostomy procedure in first stroke

It was expected that patient characteristics including age and co-morbidity would be significant factors in post-procedure mortality consistent with our previous studies. Deprivation and type of stroke were also assessed. It was hypothesised that institutional factors including case volume may also influence short term (7-day) survival post gastrostomy insertion. In addition, performance in the national stroke audit (SINAP) was assessed for relationships with outcomes following gastrostomy insertion in acute stroke.

### *Univariate Analysis*

Univariate analysis (Table 5.6) confirmed the presence of co-morbidity as a risk factor for early all-cause (crude) mortality following stroke with PEG procedure during index admission. Gender, haemorrhagic stroke, the presence of a code for dementia, age or level of deprivation had no significant effect on mortality. Odds ratio for mortality at 7 days post PEG procedure was significantly higher in low PEG volume Trusts, compared to high volume Trusts (OR 1.879, CI 1.090-3.238, p=0.02). Absolute values for mortality at 7 days were 7.8%, 6.8% and 4.3% in low, medium and high volume Trusts respectively (p=0.045). The relationship with stroke volume was less clear with a higher odds ratio for 7-day mortality observed for medium volume Trusts compared to highest volume Trusts but not for the Trusts seeing the lowest volume of stroke cases.

**Figure 5.2 Graph showing the association between Trust volume of PEG procedures and mortality for stroke patients at selected Trusts having PEG procedures in index stroke admission n=1560**

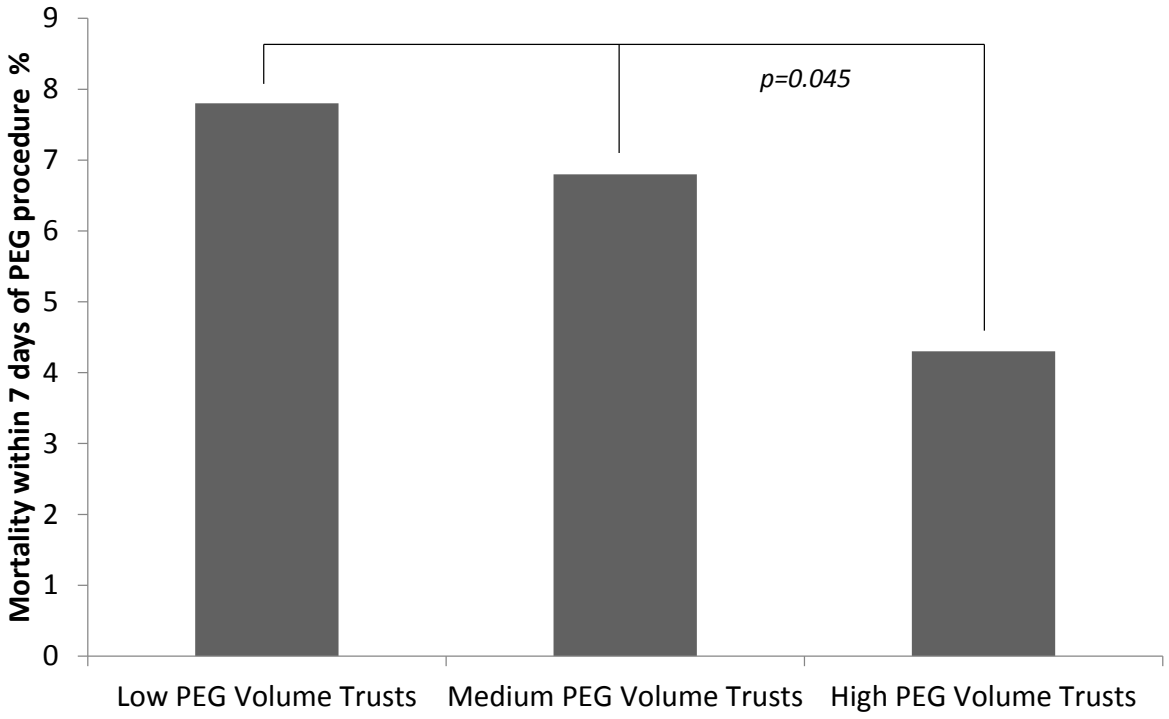
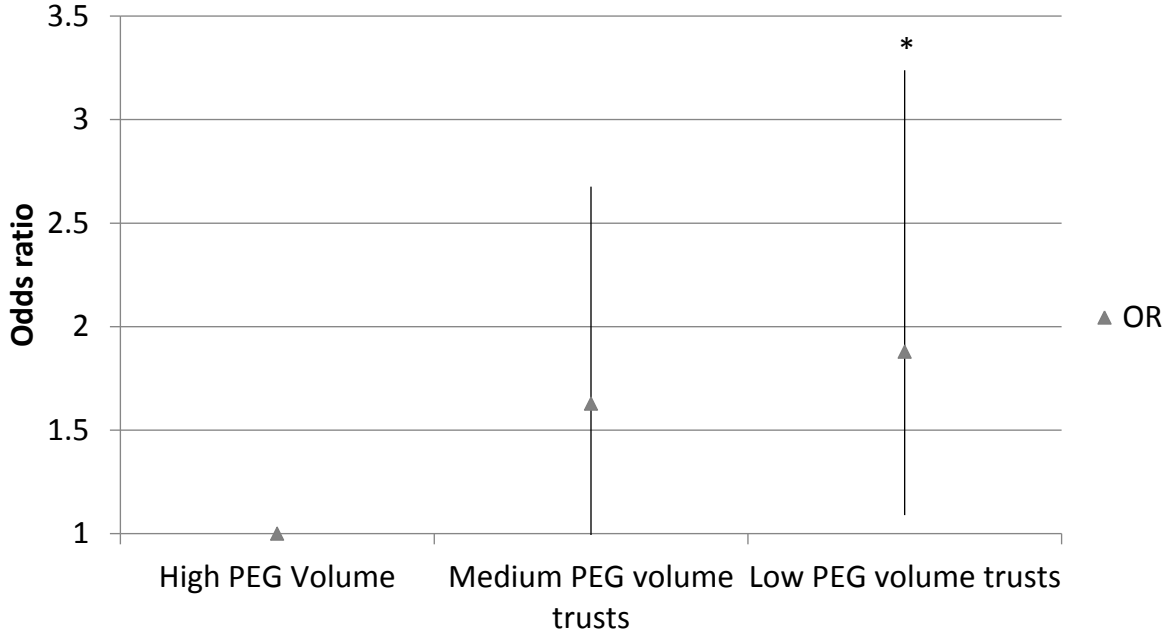



**Figure 5.3** Graph showing the association between Trust volume of PEG procedures and the ***unadjusted*** odds ratios for mortality for stroke patients at selected Trusts having PEG procedures in index stroke admission n=1560




***p*=0.023**

**Table 5.6 Univariate analysis of patient and Trust factors associated with all-cause mortality at 7 days after PEG procedure during stroke admission (n=1560)**

| Patient and Trust Factors | Unadjusted 7-day post-PEG mortality | | |
|---|---|---|---|
| | Odds ratio | 95% CI | *p* |
| **Age groups** (y) | | | |
| <55 | 1 | - | - |
| 55 – 64 | 2.294 | 0.259-20.299 | *0.455* |
| 65 – 74 | 2.256 | 0.288-17.645 | *0.438* |
| 75 – 84 | 2.115 | 0.282-15.858 | *0.466* |
| 85 + | 3.032 | 0.405-22.691 | *0.280* |
| **Co-morbidity** | | | |
| Absent | 1 | - | - |
| One | 2.039 | 1.270-3.273 | ***0.003*** |
| More than one | 2.097 | 1.167-3.769 | ***0.013*** |
| **IMD quintiles** | | | |
| Most deprived | 1 | - | - |
| 4 | 0.787 | 0.393-1.580 | *0.501* |
| 3 | 0.818 | 0.416-1.607 | *0.559* |
| 2 | 0.983 | 0.521-1.845 | *0.958* |
| Least deprived | 0.523 | 0.259-1.059 | *0.072* |
| **Gender** | | | |
| Female | 1 | - | - |
| Male | 0.933 | 0.610-1.428 | *0.751* |
| **Haemorrhagic stroke** | | | |
| Present | 1 | - | - |
| Absent | 1.100 | 0.575-2.103 | *0.773* |
| **Dementia code** | | | |
| Present | 1 | - | - |
| Absent | 1.343 | 0.657-2.745 | *0.419* |
| **SINAP score** | | | |
| High score Trusts | 1 | - | - |
| Medium score Trusts | 1.560 | 0.887-2.746 | *0.123* |

| | | | |
|---|---|---|---|
| Low score Trusts | 1.670 | 0.963-2.894 | *0.068* |
| **PEG volume** | | | |
| High volume Trusts | 1 | - | - |
| Medium volume Trusts | 1.628 | 0.990-2.676 | *0.055* |
| Low volume Trusts | 1.879 | 1.090-3.238 | ***0.023*** |
| **Stroke volume** | | | |
| High volume Trusts | 1 | - | - |
| Medium volume Trusts | 1.689 | 1.027-2.778 | ***0.039*** |
| Low volume Trusts | 1.562 | 0.912-2.678 | *0.105* |

## Multivariate analysis

Variables were analysed for independence using binary logistic regression (Table 5.7). Only those factors significant on univariate analysis were included i.e. co-morbidity, PEG volume and stroke volume. Analysis was performed in SPSS using the forward conditional method.

Compared to high volume Trusts the odds ratio for death within 7 days of PEG procedure at low volume Trusts was significantly higher at 1.869 (CI 1.082-3.227, p=0.025). The presence of one or more co-morbid conditions was confirmed as a risk factor for mortality, with an odds ratio for mortality of one co-morbid condition compared to no co-morbidity of 2.04 (CI 1.269 -3.278, p=0.003). Stroke volume was not significant with p-values for medium volume Trusts and low volume Trusts of 0.168 and 0.605 respectively.

**Table 5.7 Multivariate logistic regression analysis of factors associated with all-cause mortality following acute stroke admission with PEG procedure during index admission. Odds ratios for multiple categories (n=1560)**

| Patient and Trust Factors | Adjusted 7-day post-PEG mortality | | |
|---|---|---|---|
| | Odds ratio | 95% CI | *p* |
| **Co-morbidity** | | | |
| Absent | 1 | - | **-** |
| One | 2.040 | 1.269 -3.278 | ***0.003*** |
| More than one | 2.105 | 1.169-3.790 | ***0.013*** |
| **PEG volume** | | | |
| High volume Trusts | 1 | - | - |
| Medium volume Trusts | 1.646 | 0.999-2.712 | *0.05* |
| Low volume Trusts | 1.869 | 1.082-3.227 | ***0.025*** |

Look-up tables were created for predicting outcomes (Tables 5.8 & 5.9) from the target population of 1,560 cases of new, acute stroke with PEG insertion during the index admission. The denominator population for each category ranged from 5 to 198 cases. There is a general increase in predicted risk of mortality with increasing age and presence of risk factors identified by this study. This is seen for mortality within 7 and 30 days of PEG procedure.

**Table 5.8 All-cause mortality within 7 days of PEG insertion according to age group (y), presence of co-morbid conditions and admission to high PEG volume unit. Target population of new acute stroke admission with PEG procedure during index admission (n=1,560 patients).**

| Co-morbidity | High PEG volume Trusts | <55 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|
| No | **Yes** | 0 | 0 | 1.3% | 1.9% | 4.8% |
| No | No | 7.7% | 4.3% | 6.7% | 5.6% | 5.1% |
| **Yes** | **Yes** | 0 | 7.7% | 3.2% | 7.5% | 7.9% |
| **Yes** | No | 0 | 13.6% | 12.3% | 5.8% | 12.7% |

**Table 5.9 Table 5.8b All-cause mortality within 30 days of PEG insertion according to age group (y), presence of co-morbid conditions and admission to high PEG volume unit. Target population of new acute stroke admission with PEG procedure during index admission (n=1,560 patients).**

| Co-morbidity | High PEG volume Trusts | <55 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|
| No | **Yes** | 6.2% | 9.4% | 13.2% | 17.0% | 18.5% |
| No | No | 15.4% | 13.0% | 15.0% | 18.7% | 24.7% |
| **Yes** | **Yes** | 16.7% | 15.4% | 22.2% | 29.3% | 35.6% |
| **Yes** | No | 20.0% | 22.7% | 26.3% | 20.5% | 32.7% |

### *PEG procedure volume*

Having found that procedure volume is a potential factor in early mortality after gastrostomy insertion, it was important to try and identify any differences between low and high volume Trusts that might account for this result - What is it about those institutions performing higher numbers of PEG procedures that means their post procedure mortality in stroke is significantly lower than lower volume hospitals? Is it better case selection, better stroke services in general, or simply that practice makes perfect? Table 5.8 shows the results of these comparisons. The total stroke population (n=42,550) was compared across each tertile and statistically significant differences were seen. The mean age of those patients in low volume centres was higher than in the medium and high volume Trusts. The spread of patients across the age groups differed between the tertile groups with a higher proportion of younger patients in the high PEG volume tertile population. However, age was not found to be a significant factor in early PEG mortality. Additionally, people admitted to high PEG volume Trusts were more likely to be from the more deprived wards compared to the low and medium volume tertiles. The most deprived accounted for 27% of stroke admissions to high volume Trusts compared to 18% in the low PEG volume tertile (*p<0.001*). Similarly, only 14% of patients admitted to the high volume centres were from the least deprived areas compared to 18% in the lowest volume Trusts (p<0.001). Higher levels of deprivation tend to be associated with worse outcomes although deprivation tertiles were not found to have significant effects on mortality by univariate analysis. Comparing the stroke population who had a gastrostomy insertion across the volume tertiles gave similar findings (Table 5.9). Low volume Trusts had slightly older patients but they were

likely to be less deprived than in the high volume centres. No significant difference in the number of co-morbid conditions coded was found. It should also be noted that the average time to PEG insertion from admission with acute stroke did not differ between the volume tertiles. This may indicate equivalent access to PEG services and similar decision making with regards to nutrition support in stroke. Although the high PEG volume tertile group of Trusts had greater absolute numbers of stroke cases and hence the greatest share of total PEG-stroke cases in the study, the proportion of these Trusts with *any* 7-day mortality case was not significantly higher than the other tertiles. (Low PEG volume tertile: 46% of Trusts had no 7-day deaths; Middle: 50%; High PEG volume tertile: 44%; $p>0.05$)

We also compared performance in the national stroke audit 2008 using the mean composite score for each Trust and comparing the overall mean for each volume tertile (see next section). No significant difference in composite score across the volume tertiles was found. Although there was a trend for those Trusts with the lowest average SINAP score to have the highest PEG mortality at 7 days this was not statistically significant as shown in Figure 5.5. The swallow assessment score did not show any correlation with mortality rates.

**Table 5.9 Comparison of population characteristics for PEG volume tertiles for total stroke population n=42,550**

| | Low PEG volume Trusts<br>n= 9826 | Medium PEG volume Trusts<br>n= 13919 | High PEG volume Trusts<br>n= 18805 | *p*<br>(†ANOVA. Others all $\chi^2$) |
|---|---|---|---|---|
| **Mean age in years (range, sd)** | 78.25 (16-103, 11.962) | 77.96 (17-103, 12.073) | 77.00 (16-106, 12.661) | ***p<0.001†*** |
| **Age groups (n)** | | | | |
| **<55 years** | 5.1% (497) | 5.1% (712) | 6.5% (1213) | ***p<0.001*** |
| **55 – 64** | 7.6% (749) | 7.7% (1067) | 8.4% (1574) | |
| **65 – 74** | 16.4% (1612) | 17.0% (2373) | 18.3% (3440) | |
| **75 – 84** | 37.0% (3639) | 37.3% (5188) | 36.5% (6873) | |
| **85 +** | 33.9% (3329) | 32.9% (4579) | 30.3% (5705) | |
| **Male (n)** | 43.2% (4242) | 43.6% (6069) | 44.0% (8276) | *p=0.39* |
| **Co-morbidity Group (n)** | | | | |
| **No co-morbidity** | 58.6% (5757) | 57.7% (8038) | 57.3% (10783) | *p=0.127* |
| **One coded** | 26.6% (2616) | 27.2% (3791) | 26.6% (5007) | |
| **More than one** | 14.8% (1453) | 15.0% (2090) | 16.0% (3015) | |
| **Haemorrhagic stroke (n)** | 9.3% (917) | 10.4% (1441) | 11.2% (2112) | ***p<0.001*** |
| **Dementia (n)** | 9.2% (908) | 8.8% (1230) | 9.1% (1710) | *p=0.54* |
| **Deprivation Quintile (n)** | | | | |
| **Most deprived** | 17.7% (1738) | 17.4% (2418) | 27.4% (5157) | ***p<0.001*** |
| **2** | 21.8% (2142) | 20.7% (2879) | 21.7% (4084) | |
| **3** | 22.0% (2161) | 21.5% (2998) | 19.3% (3619) | |
| **4** | 21.0% (2067) | 21.7% (3021) | 17.3% (3243) | |
| **Least deprived** | 17.5% (1717) | 18.7% (2600) | 14.3% (2692) | |
| **(14 cases missing)** | | | | |
| **Mean length of stay in days (range, sd)** | 30.76 (8-179, 27.147) | 30.10 (8-178, 25.838) | 30.25 (8-182, 26.073) | *p=0.095†* |
| **Mean SINAP score for Trusts within each tertile** | 70.6 (39.9-90.9, 11.96) | 72.9 (40.5-96.1, 11.69) | 71.8 (50.7-97.6, 11.28) | *p=0.64* |

**Figure 5.4 Chart showing the association between the volume of PEG procedures at hospital Trusts and the mean of the SINAP average scores for Trusts within each volume tertile (n=137Trusts)**

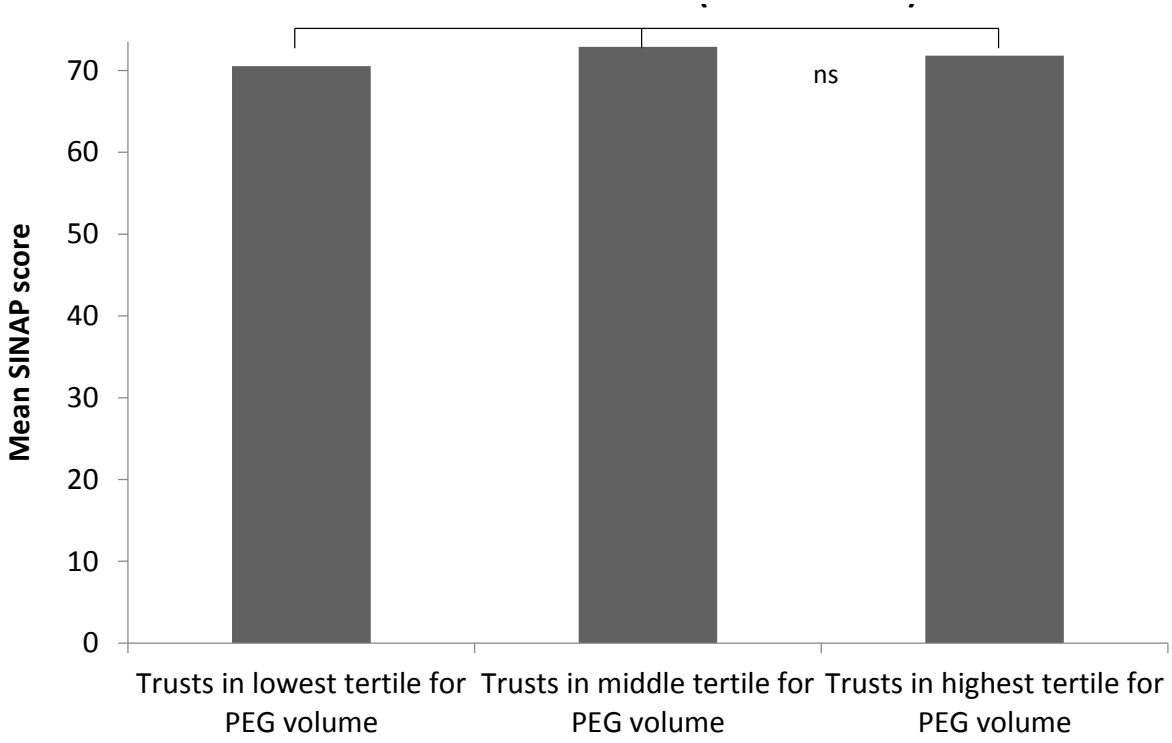



**Figure 5.5 Chart showing the association between average SINAP score for hospital Trusts and mortality within 7 days of PEG procedure for acute stroke patients having PEG procedures during their index stroke admission (n=1560)**

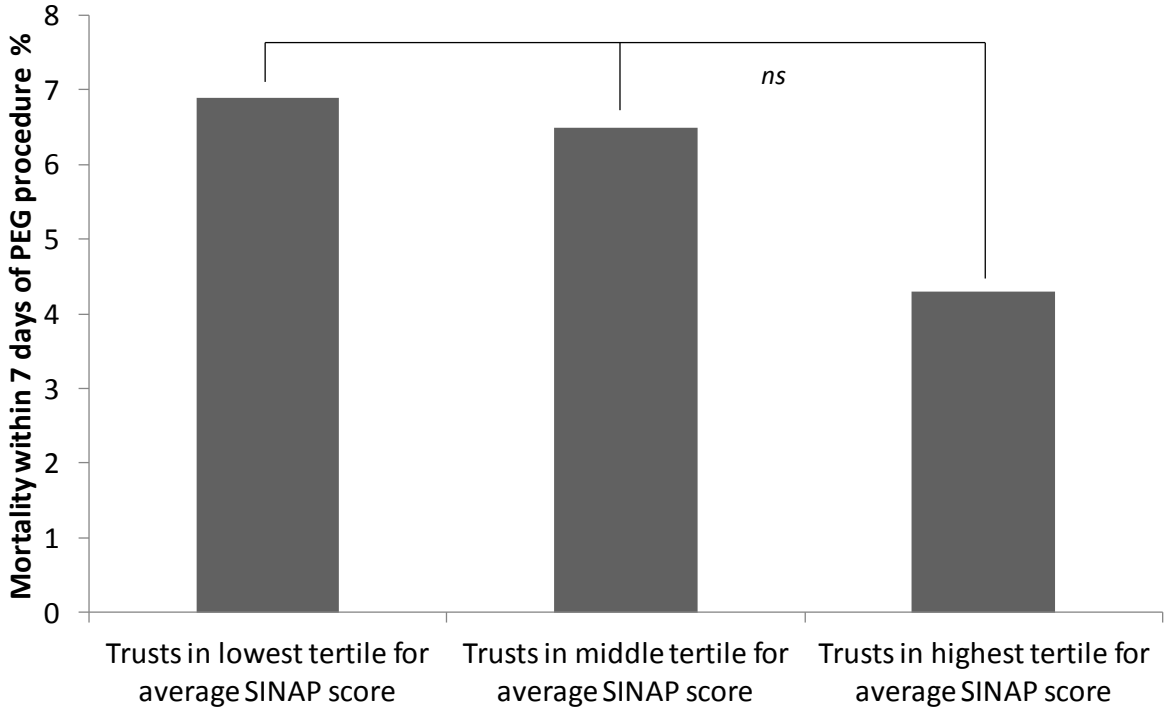


**Table 5.10 Comparison of population characteristics for PEG volume tertiles for those stroke patients having gastrostomy insertion during their index admission (n=1560)**

| | Low PEG volume Trusts n= 322 | Medium PEG volume Trusts n= 515 | High PEG volume Trusts n= 723 | *p* (†ANOVA. Others all $\chi^2$) |
|---|---|---|---|---|
| **Mean age in years (range, sd)** | 80.7 (28-98, 8.830) | 79.3 (38-99, 9.966) | 78.5 (23-100, 10.785) | ***p=0.004†*** |
| **Age groups (n)** | | | | |
| **<55 years** | 1.2% (4) | 2.7% (14) | 3.0% (22) | *p=0.227* |
| **55 – 64** | 3.7% (12) | 6.4% (33) | 6.2% (45) | |
| **65 – 74** | 13.4% (43) | 14.4% (74) | 19.2% (139) | |
| **75 – 84** | 45.0% (145) | 43.5% (224) | 40.4% (292) | |
| **85 +** | 36.6% (118) | 33.0% (170) | 31.1% (225) | |
| **Male (n)** | 43.2% (139) | 46.4% (239) | 48.4% (350) | *p=0.3* |
| **Co-morbidity Group (n)** | | | | |
| **No co-morbidity** | 55.0% (177) | 57.3% (295) | 56.3% (407) | *p=0.81* |
| **One coded** | 29.2% (94) | 30.3% (156) | 29.3% (212) | |
| **More than one** | 15.8% (51) | 12.4% (64) | 14.4% (104) | |
| **Haemorrhagic stroke (n)** | 13.7% (44) | 10.7% (55) | 14.5% (105) | *p=0.13* |
| **Dementia (n)** | 5.9% (19) | 6.8% (35) | 9.1% (66) | *p=0.13* |
| **Deprivation Quintile (n)** | | | | |
| **Most deprived** | 17.7% (57) | 20.0% (103) | 31.3% (226) | ***p<0.001*** |
| **2** | 20.2% (65) | 25.0% (129) | 20.2% (146) | |
| **3** | 21.4% (69) | 20.0% (103) | 18.1% (131) | |
| **4** | 21.1% (68) | 18.6% (96) | 15.9% (115) | |
| **Least deprived** | 19.6% (63) | 16.3% (84) | 14.4% (104) | |
| **Mean number of days from admission to PEG procedure (range, sd)** | 33.8 (8-148, 19.196) | 31.4 (8-119, 18.082) | 33.3 (8-144, 21.136) | *p=0.13†* |
| **Length of stay in days (range, sd)** | 68.7 (9-178, 34.584) | 63.8 (9-174, 31.766) | 65.1 (13-178, 33.147) | *p=0.11†* |

## Validation and comparison with national audit results

The Royal College of Physicians published data from the 2008 stroke audit[243] which included results for 132 of the 137 Trusts in our final analysis.

The 2008 SINAP audit limited the number of stroke cases that could be submitted. Therefore, to validate our case capture, we used data from the 2011 national stroke audit which provided data on 12-month totals for stroke admissions and did not limit the number of cases that could be entered by each Trust. Stroke numbers are compared in Table A5.2 in Appendix 7.5. Of our 137 selected Trusts SINAP 2011 had data for 48. Some data could not be assigned due to merges of Trusts particularly in the London area. Audit data was from a 3 month period with historical totals provided for the 12 months April 2010 – March 2011. Subarachnoid haemorrhage, subdural and extradural haemorrhage were excluded as in our study. TIAs were included in initial counts in the SINAP audit but excluded from final analysis. The numbers presented here exclude TIAs. The SINAP data suggests incomplete data capture with yearly totals of stroke patients fewer than the total for 3 months in some cases. Where the 12-month totals were greater than that for 3 months the number was frequently still fewer than would be expected (i.e. fewer than 4 times the 3 month total). Apart from 2 Trusts our totals from HES were greater than the SINAP data. At least one of these Trusts is a tertiary neurosurgical centre from where patients may be repatriated to other Trusts. The SINAP data cleaning process attempted to account for duplicate entries due to this repatriation but it was not clear where the final assignment was made (the local or tertiary hospital). This may account for the HES totals being lower for these Trusts. Overall these comparisons

suggest that our HES capture is good. Cases are not being missed but old cases may have inadvertently been included.

## Discussion

This study has shown an association between PEG procedure volume and early post-procedure mortality in patients with new acute stroke. Mean mortality within 7 days of PEG procedure in high volume Trusts was half that of low volume Trusts (Fig 5.2 p=0.045).

Early mortality after a procedure is suggestive of poor patient selection (too sick to benefit), or poor quality procedure (procedure complications). Volume of exposure (to disease or procedure) may be seen as a surrogate marker for service quality. It was hypothesised that those Trusts performing higher numbers of PEG procedures would be more likely to have established nutrition services, nurse specialists, designated endoscopists for PEG procedures and that patient selection and procedural expertise is better. The higher mortality in patients with co-morbid disease may indicate poor patient selection; however the co-morbid load appeared to be higher in the high PEG volume tertile population which had the lowest mortality. Overall, the population characteristics were very similar across the volume tertiles for patients having a gastrostomy inserted. This would support the theory that rather than poor patient selection it is the procedure itself that is the cause of differences in mortality.

Our stroke and PEG mortality rates were consistent with those previously reported in the literature [196;227;228;230] . The stroke rate reported in the national guideline for Stroke[196] for the whole of the UK was 174 to 216 people per 100,000 people per year. This would give a range for England of 90,480 to 112,320, given a population in England of about 52 million. These figures included TIA and subarachnoid

haemorrhage, conditions that we excluded. Thus, our figure of 87,507 new stroke admissions (80,113 emergency admissions) would appear to be genuine. The rate of PEG insertions in stroke patients varies amongst studies with significant differences found in the denominator populations studied. There are also acknowledged differences in practice internationally that makes comparisons difficult. The SINAP 2011 study[242] included far fewer patients than the number we captured within HES data. This is explained by their acknowledged incomplete data collection from many units, and relied on stroke teams entering their own data into the SINAP dataset.

By using the SINAP audit data it was hoped to create a useful clinical indicator that could be derived from HES data and used to assess performance in stroke care. It was hypothesised that PEG mortality figures would correlate with scores in the SINAP swallow assessment indicator. No such relationship was found. There was the suggestion of a numerical trend for reducing 7-day mortality across the SINAP performance tertiles (low through medium to high) but this did not reach significance.

Fewer than half the patients in our dataset had co-morbid conditions coded. This seems surprisingly low. The higher number of co-morbid conditions coded by the high procedure volume Trusts may well reflect better coding rather than a true difference in population characteristics. Evaluation of previous admissions and episodes of care using linkage of data via HESID is possible and could provide further detail on co-morbid diseases.

Mortality rates without specific adjustment for stroke severity may be seen as inadequate for use as a performance measure. However, our analysis did look at a

defined sub-population of stroke patients; those requiring a minimum length of stay and a PEG procedure. As such, those with very mild strokes or those with catastrophic strokes would have been excluded.

Given the relatively low event rate there is a possibility of a Type II error. However, if a power calculation is performed for a doubling of mortality rate from approximately 4% to 8% as we saw for 7-day mortality between high volume centres and low volume centres then the sample size required for a power of 80% with 0.05% significance is 553. The low volume population contained 322 patients, the high volume population 723. (See Fig 5.2 and Table 5.11)

HES data does not allow assessment of stroke severity other than by surrogate markers such as mortality, length of stay and place of discharge. We did not make an assessment of where a patient was admitted from (e.g. own home or nursing home) which could provide additional predictors for poor outcome and allow further risk adjustment. The use of other methods of feeding such as naso-gastric tube and parenteral nutrition are not specifically or reliably coded for in HES (X90.4 is intravenous nutrition; X90.8 & X90.9 are both high cost haematology and nutrition drugs). Incorporation into HES of scores from validated stroke severity measures e.g. NIHSS, would facilitate further assessment of the impact of PEG insertions in stroke. Unfortunately it is not possible to derive such scores from data held within the HES database at this time.

Those patients requiring a PEG following acute stroke are presumed to be different to those stroke patients not requiring a PEG. If the aim is to assess the impact of PEG on stroke outcomes then both populations need to be assessed with

appropriate case-matching. Without an assessment of stroke severity it is difficult to exclude the possibility that those institutions with lower mortality rates are placing PEGs in lower risk cases. As it appeared that those institutions with a high volume of PEG insertions generally had a lower mortality rate this may simple reflect that they have a lower threshold for inserting PEGs in stroke patients.

The 'look-up' tables developed for predicting outcome following PEG insertion in stroke were limited by small numbers for some sub-groups. The increasing risk was not consistent with the addition of our defined risk factors. So, for example, in some age groups being in a high volume centre gave a higher risk of death within 30 days compared to being in a low volume centre. This suggests that there are other factors at play in determining outcome for these patients. The most significant factor is probably stroke severity which we were not able to adequately define using HES data.

## Conclusions

Having a PEG procedure following stroke is a marker of worse long-term outcome consistent with a more severe stroke. Short-term mortality varies amongst hospital Trusts with those performing the highest volumes of PEG procedures having the lowest post procedure mortality (within 7 days of gastrostomy procedure). Short-term mortality after PEG procedures is a candidate marker for the quality of hospital care for acute dysphagic stroke. Further work is required to identify the precise reasons for lower mortality in high volume institutions so that appropriate performance management can be directed to those with higher mortality rates. Studying a larger number of events by looking at sequential years of data may make the study more statistically robust and reduce the risk of a Type II error.

# 6. Discussion

# 6. Discussion

Our general clinical findings are perhaps not that surprising - patient factors are the major determinants of future health and outcomes. However, these unsurprising results are reassuring in our quest to show that routinely collected administrative data and in particular HES data, can be used for good quality outcomes analysis. Our message is in keeping with previous work. What we have been able to do is qualify and quantify our results with robust statistics for a whole population, rather than being based on single-centre experiences or on a sub-group of volunteer units[118]. Case ascertainment is likely to be without systematic bias since inpatient episodes are recorded routinely in HES irrespective of case severity or outcome.

Mortality is derived from the official statutory national death registry. This is the most accurate record of alive-dead status available. In terms of providing accurate figures for use in discussion with health professionals, patients and carers this is invaluable. We have identified variation at Trust level most of which appears to be within acceptable limits. We have highlighted areas for further analysis and improved case-mix adjustment.

We sought feedback from clinicians to guide our analyses and focussed on first rather than repeat procedures and tracked information contained in readmissions to examine last-coded diagnoses before death. The use of case linkage is an area to be developed so that performance can be tracked over years – likely to be far more useful than 12-month data. It will allow measurement of improvement following implementation of new policies and guidance.

The large numbers of cases accessible with HES data are particularly important when monitoring for rare events e.g. complications post endoscopy. This is a major advantage over internal audit and clinical databases. Endoscopy units in the UK are encouraged to audit 30-day mortality and morbidity but the NHS currently lacks systems that can capture all procedures and link to subsequent outcome. Our analysis shows HES data, in combination with death registry status, can be used for Trust level monitoring.

We analysed mortality rates after procedures up to 30 days and beyond. It is our belief that measuring mortality rates within 7 days of a procedure provides a better marker of procedure quality and outcome. Beyond 7 days the influence of other factors, particularly disease progression, has a significant effect on outcomes and the procedure itself becomes less relevant.

Weaknesses of our approach relate mainly to the relative paucity of clinical data within HES data and the potential for coding incompleteness or inaccuracy. Hence, global grading of illness severity and other clinical or laboratory indices of acute illness are not recorded and it is not possible to judge the severity of the presenting illness from the basic ICD-10 diagnostic coding system. However, the basic case mix observed in the present study was very similar to a prospective study based on richer clinical datasets[129] suggesting that HES data contains a representative sample of patients undergoing endoscopic procedures.

There is published evidence that administrative data can match clinical data sets[244] and that the coding quality for specific procedures is good[245]. There have been a number of incentives to drive improvements in coding accuracy in recent years. These include financial incentives such as 'payment by results' whereby patient-level coding determines a hospital's tariff-based income and the publication of HES based performance data e.g. Dr Foster's The Good Hospital Guide. The number of ICD diagnostic code positions within HES has increased with upgrades of the HES dataset. It was evident from our two datasets that coding depth had increased. Phenomena such as 'death code creep' where more diagnoses are listed where a patient dies than in patient episodes where they survive can add to variation in coding practice[20]. Under-coding of co-morbid conditions is recognised but is likely to improve with increasing front-line awareness of tariff calculations and HES data in general.

Our use of mortality as an outcome measure by which hospital performance can be measured has limitations. Mortality rates do not necessarily equate to quality of care. Many factors affect mortality and not all can be controlled for. Even if complete risk adjustment is performed, caution in interpreting results is required as

risk will not be the same across all institutions or geographic area – the 'constant risk fallacy'. Rates of hospitalization and mortality vary across hospitals, regions and nations. This variation can persist even after risk-adjustment. What remains does not necessarily equate to variation in quality[20;246]. Practice may simply be different and finding variation should thus be a stimulus for investigating further.

Grouping cases by diagnosis proved difficult and unsatisfactory. A single episode of care can be coded in many ways with several combinations of ICD and OPCS codes possible. Most codes were used very infrequently and even the most commonly used accounted for a minority of patients – the top ten diagnostic codes accounted for fewer than a quarter of all diagnoses in our PEG study population. Grouping codes together is not straightforward although it theoretically makes comparing groups of patients easier and the data more manageable. Grouping of codes is used for tariff calculations with HRGs. However, these are not always clinically coherent groups and thus have limited use in outcomes research.

Analysis of HES data is not a simple process and there are significant issues with the level of coding of co-morbidities and allocating care to the right consultant. Investigating the data at a national level has proved more difficult than originally anticipated. Acknowledging a significant learning curve to learn how to manipulate data and perform analysis, it still took many months of work to produce the data for my thesis. HES analysis may not be quicker than traditional clinical audit but it does have some advantages in terms of data consistency and evaluation of time. These factors make it a more suitable tool for benchmarking performance and outcomes.

Currently most Trusts use outside agencies to analyse their HES data e.g. Dr Foster and CHKS. These agencies are employed to analyse performance, against evolving national standards of care and targets. They have the manpower, skill sets and IT support to manipulate these huge datasets and produce results in a relatively short space of time.

HES analysis by individual clinicians is probably unrealistic at this point without the appropriate IT and data analyst support and as such is not going to entirely replace the more traditional methods of clinical audit using direct case note review.

Individual Trusts do not have routine access to HES data for other Trusts, only the final published outcome results. Thus, investigation of HES data on a national level is likely to be limited to the commercial sector and individual research groups. However, using HES data at local Trust level to monitor outcomes and performance is feasible and is happening and clinicians do need to engage with that process. The development of clinical metrics will involve HES data and requires clinician engagement to make them meaningful.

Data can be misinterpreted and there are many caveats to presenting the data in terms of case mix adjustment and clinical context. Analysis of HES data requires a multi-disciplinary team of investigators with appropriate IT skills and clinical experience i.e. needs clinicians as well as data analysts.

Are HES a useful resource for process and outcomes analysis? I have shown that HES can be used to assess outcomes within gastroenterology on a national level and at Trust level but that it will not entirely replace more traditional methods of clinical audit. Results from HES analysis may be a trigger for more clinically detailed local audit and enable fuller case ascertainment.

Assessing process proved more difficult. Correlating results from HES analysis with measures of process such as the SINAP audit in the Stroke chapter was unsatisfactory but linkage of episodes, such as that done in the ERCP chapter, can begin to describe processes within healthcare. Further work on the processes involved in healthcare has been carried out and published on, by colleagues in the Aintree Health Outcomes Partnership group.

## The Future

Future analysis using provider spells of care rather than finished consultant episodes may provide more clinically coherent analysis and enable appropriate comparison with American healthcare datasets.

Variables within the HES dataset such as admission source, postcode and deprivation score need to be investigated further as potential means of measuring patients' pre-morbid status which would allow further case-mix adjustment.

A more complete picture of a patient's journey through the healthcare system is achievable through linkage of episodes of care over time and across institutions.

The HES dataset could be improved with the introduction of codes that provide information on the stage or grade of disease. These would provide greater clinical depth, aid case-mix adjustment and perhaps reduce inaccuracies and bias (non-clinical variation in diagnostic practice; geographical variation in coding practices). For example, NIHSS stroke severity, providing a value for ejection fraction alongside a diagnosis of heart failure, or TMN staging for neoplasms would improve the clinical validity of coded data. Likewise, codes for risk factors such as smoking would benefit risk-adjustment processes[247]. Providing dates with diagnostic codes akin to the OPCS procedure coding system e.g. the first time they are used for a patient could improve interpretation of data and allow for more in-depth analysis of cause and effect.

Improving the quality of the data that is put into HES relies significantly on engaging the clinicians themselves and encouraging them to liaise more closely with their hospital coding teams. Self-coding by clinicians already occurs with surgeons entering OPCS codes themselves when completing theatre reports. The use of tick-box discharge summaries with specific diagnoses and their codes is becoming more widespread across all specialities. This encourages true diagnostic codes to be used rather than non-specific symptom codes. Both strategies will improve the quality of and confidence in coding data. Education on specific complication codes and improvement in that code set would greatly assist outcomes analysis.

As clinicians, hospital IT and audit staff become more familiar with HES, the process of analysing the data will become more streamlined and efficient. It is important for groups using HES data to be transparent about the methods they use. This is not just to enable appropriate comparisons and interpretation of their results but to allow sharing of knowledge. Cleaning and manipulating HES data into a useable form is a complex process. As strategies and techniques, pitfalls and quirks are recognised this information needs to be disseminated so that rigorous methods can be universally applied to data analysis.

Appropriately trained and skilled staff from both clinical and IT backgrounds are required to handle data and data collection and to perform analysis and interpretation. This has probably been lacking in the NHS so far. Better IT can help improve efficiency. Other than staff numbers this is perhaps the major factor explaining the US, non-profit, health maintenance organisation, Kaiser Permanente's better cost efficiency compared to the NHS[248]

Increased efficiency in HES analytical methods will result in more timely analysis increasing its usefulness for performance monitoring. Caution is still required however. The problem of unstable data and quality measures has been recognised[30]. Performance indicators change over time (e.g. time to be seen, door to needle times etc). Definitions change, leading to changes in the numerator and denominator populations. Defining the baseline performance becomes difficult and assessing trends over time may become meaningless because of this instability. Data entry performance can change due to increased depth of coding; revisions of the OPCS and ICD code systems and focus on particular diseases or procedures at local or national level.

In 2010 the Standardized Nomenclature of Medicine - Clinical Terms (SNOMED CT) system was linked with the WHO Family of Classifications system following collaboration between WHO and International Health Terminology Standards Development Organisation. Data from the two systems are now complementary and can be used to summarize information from patient care episodes into aggregated results for healthcare research, policy and service provision[44].

The publication of HES based analysis must be in context with appropriate caveats made clear. This is particularly so when in the public domain. League tables for hospitals (e.g. Dr Foster's Good Hospital guide) may over-simplify to the detriment of the hospitals concerned. By ranking hospitals it is implied that those at the bottom of the league are performing badly when in fact their performance may be within acceptable limits (and safe) with scores simply below the average at the time of assessment. The difference between and the implications of 'common-cause' variation rather than 'special cause' must be made clear. How much variation is

allowed in healthcare is a complex issue for debate. The importance of clinical versus statistical significance must be made clear.

Using HES data for individual doctor level analysis is happening within the NHS but is unreliable at this time. The consultant code applied to an episode was frequently incorrect when data for our own institution was analysed. Even if the code denotes the correct consultant team, procedures within that episode may not have been performed by that individual. The consultant identified may not physically have seen that patient. Even if the correct consultant is identified it would be dangerous and inappropriate to assign all outcomes to that individual. A patient's journey involves many members of staff and complex decision processes – it is a team effort.

At national level HES has a place in generating robust answers to clinical questions that can be used in guiding and advising clinicians, patients and their carers. For example, what is the risk of a poor outcome following ERCP in a 35 year old fit and well woman with gallstones? What is the risk in an 85 year old admitted as an emergency with cholangitis? What is the prognosis for a 50 year old man with a stroke who requires nutritional support via PEG? And perhaps, which hospital should he be going to?

At Trust level I believe HES can be used to highlight variation in performance between institutions, assess whether the variation is of concern and provide direction for further investigation. However, we need to move beyond crude mortality rates to more sophisticated indicators.

I do not believe that the full potential of HES data analysis has yet been realised. It is not the perfect solution to outcomes analysis and performance monitoring in healthcare but the more we engage with it the more valuable a resource it will become.

***"The scientific purist, who will wait for medical statistics until they are nosologically exact, is no wiser than Horace's rustic waiting for the river to flow away"[249] - Major Greenwood English; epidemiologist and statistician (9th August 1880 - 5th October 1949)***

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# 7. Appendices

## 7.1. Syntax

## ERCP Syntax 1 – ERCP present

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OPERTN10='J425'|
OPERTN10='J428'|
OPERTN10='J429'|
OPERTN10='J431'|
OPERTN10='J432'|
OPERTN10='J433'|
OPERTN10='J438'|
OPERTN10='J439'|
OPERTN10='J441'|
OPERTN10='J448'|
OPERTN10='J449'|
OPERTN10='J451'|
OPERTN10='J452'|
OPERTN10='J453'|
OPERTN10='J458'|
OPERTN10='J459')ER
CPPRESENT = 1.
EXECUTE.

IF
(OPERTN11='J381'|
OPERTN11='J382'|
OPERTN11='J388'|
OPERTN11='J389'|
OPERTN11='J391'|
OPERTN11='J398'|
OPERTN11='J399'|
OPERTN11='J401'|
OPERTN11='J402'|
OPERTN11='J403'|
OPERTN11='J404'|
OPERTN11='J405'|
OPERTN11='J406'|
OPERTN11='J407'|
OPERTN11='J408'|
OPERTN11='J409'|
OPERTN11='J411'|
OPERTN11='J412'|
OPERTN11='J413'|
OPERTN11='J414'|
OPERTN11='J418'|
OPERTN11='J419'|
OPERTN11='J421'|
OPERTN11='J422'|
OPERTN11='J423'|
OPERTN11='J424'|
OPERTN11='J425'|
OPERTN11='J428'|
OPERTN11='J429'|
OPERTN11='J431'|
OPERTN11='J432'|
OPERTN11='J433'|
OPERTN11='J438'|
OPERTN11='J439'|
OPERTN11='J441'|
OPERTN11='J448'|
OPERTN11='J449'|
OPERTN11='J451'|
OPERTN11='J452'|
OPERTN11='J453'|
OPERTN11='J458'|
OPERTN11='J459')ER
CPPRESENT = 1.
EXECUTE.

IF
(OPERTN12='J381'|
OPERTN12='J382'|
OPERTN12='J388'|
OPERTN12='J389'|
OPERTN12='J391'|
OPERTN12='J398'|
OPERTN12='J399'|
OPERTN12='J401'|
OPERTN12='J402'|
OPERTN12='J403'|
OPERTN12='J404'|
OPERTN12='J405'|
OPERTN12='J406'|
OPERTN12='J407'|
OPERTN12='J408'|
OPERTN12='J409'|
OPERTN12='J411'|
OPERTN12='J412'|
OPERTN12='J413'|
OPERTN12='J414'|
OPERTN12='J418'|
OPERTN12='J419'|
OPERTN12='J421'|
OPERTN12='J422'|
OPERTN12='J423'|
OPERTN12='J424'|
OPERTN12='J425'|
OPERTN12='J428'|
OPERTN12='J429'|
OPERTN12='J431'|
OPERTN12='J432'|
OPERTN12='J433'|
OPERTN12='J438'|
OPERTN12='J439'|
OPERTN12='J441'|
OPERTN12='J448'|
OPERTN12='J449'|
OPERTN12='J451'|
OPERTN12='J452'|
OPERTN12='J453'|
OPERTN12='J458'|
OPERTN12='J459')ER
CPPRESENT = 1.
EXECUTE.

IF
(OPERTN13='J381'|
OPERTN13='J382'|
OPERTN13='J388'|
OPERTN13='J389'|
OPERTN13='J391'|
OPERTN13='J398'|
OPERTN13='J399'|
OPERTN13='J401'|
OPERTN13='J402'|
OPERTN13='J403'|
OPERTN13='J404'|
OPERTN13='J405'|
OPERTN13='J406'|
OPERTN13='J407'|
OPERTN13='J408'|
OPERTN13='J409'|
OPERTN13='J411'|
OPERTN13='J412'|
OPERTN13='J413'|
OPERTN13='J414'|
OPERTN13='J418'|
OPERTN13='J419'|
OPERTN13='J421'|
OPERTN13='J422'|
OPERTN13='J423'|
OPERTN13='J424'|
OPERTN13='J425'|
OPERTN13='J428'|
OPERTN13='J429'|
OPERTN13='J431'|
OPERTN13='J432'|
OPERTN13='J433'|
OPERTN13='J438'|
OPERTN13='J439'|
OPERTN13='J441'|
OPERTN13='J448'|
OPERTN13='J449'|
OPERTN13='J451'|
OPERTN13='J452'|
OPERTN13='J453'|
OPERTN13='J458'|
OPERTN13='J459')ER
CPPRESENT = 1.
EXECUTE.

IF
(OPERTN14='J381'|
OPERTN14='J382'|
OPERTN14='J388'|
OPERTN14='J389'|
OPERTN14='J391'|
OPERTN14='J398'|
OPERTN14='J399'|
OPERTN14='J401'|
OPERTN14='J402'|
OPERTN14='J403'|
OPERTN14='J404'|
OPERTN14='J405'|
OPERTN14='J406'|
OPERTN14='J407'|
OPERTN14='J408'|
OPERTN14='J409'|
OPERTN14='J411'|
OPERTN14='J412'|
OPERTN14='J413'|
OPERTN14='J414'|
OPERTN14='J418'|
OPERTN14='J419'|
OPERTN14='J421'|
OPERTN14='J422'|
OPERTN14='J423'|
OPERTN14='J424'|
OPERTN14='J425'|
OPERTN14='J428'|
OPERTN14='J429'|
OPERTN14='J431'|
OPERTN14='J432'|
OPERTN14='J433'|
OPERTN14='J438'|
OPERTN14='J439'|
OPERTN14='J441'|
OPERTN14='J448'|
OPERTN14='J449'|
OPERTN14='J451'|
OPERTN14='J452'|
OPERTN14='J453'|
OPERTN14='J458'|
OPERTN14='J459')ER
CPPRESENT = 1.
EXECUTE.
```

## ERCP Syntax 2 – HESIDpresent

```
COMPUTE HESIDPRESENT = 0.
EXECUTE.
IF (HESID = 18800060|
HESID = 70913961|
HESID = 8780583|
HESID = 45766269|
HESID = 43578500|
HESID = 34888107|
HESID = 63550836|
HESID = 45192211|
HESID = 1446345|
HESID = 71792184|
HESID = 1751740|
HESID = 22108071|
HESID = 51714698|
HESID = 72252617|
HESID = 4211157|
HESID = 33027459|
HESID = 32745262|
HESID = 63349552|
HESID = 1455726|
HESID = 65708126|
HESID = 68939140|
HESID = 64858981|
HESID = 75952149|
HESID = 19998269|
HESID = 1116986|
HESID = 51827795|
HESID = 15461225|
HESID = 76035284|
HESID = 75954017|
HESID = 32855553|
HESID = 7470099|
HESID = 72661721|
HESID = 34525771|
HESID = 1109754|
HESID = 8825707|
HESID = 76000930|
HESID = 25644418|
HESID = 14546682|
HESID = 22987502|
HESID = 1542822|
HESID = 10073431|
HESID = 8277847|
HESID = 8863616|
HESID = 76010404|
HESID = 13517688|
HESID = 2191457|
HESID = 1253637|
HESID = 74163783|
HESID = 32004108|
HESID = 3489522|
HESID = 717978|
HESID = 14949519|
HESID = 51693971|
HESID = 1483217|
HESID = 2115559|
HESID = 46905165|
HESID = 1725999)HESIDPRESENT
= 1.
EXECUTE.
```

## ERCP Syntax 3 – New HESID present

```
COMPUTE HESIDPRESENTNEW = 0.
EXECUTE.
IF (EXTRACTHESID =
'0D6B2D906C735DFEF775528AF58C1B06'|
EXTRACTHESID = '2EABF067C69154B6BD5A916F39F9B41F'|
EXTRACTHESID = '0A9453FECEB4F918D094FB00C1D1A7D0'|
EXTRACTHESID = '1A246B96AE163B068A07F4BC43A1FA30'|
EXTRACTHESID = '02E9726685C636F288CC2E639C749513'|
EXTRACTHESID = '2EE6C3F080B86BDDC6417B875A47B09D'|
EXTRACTHESID = '31A3E871847319E5906C614DCAED4BC4'|
EXTRACTHESID = '23D8FC7134BAB4CE65C4F488388A8B57'|
EXTRACTHESID = '0D12AAB7C543DEEBB5C6859E2361CCB5'|
EXTRACTHESID = '0DFB85D2823E9B9549397737431F6719'|
EXTRACTHESID = '25930710EE518DC1B1A9ACB8B9FBBF23'|
EXTRACTHESID = '26ADBCADA4A8C8AB62B7868CB1E8A35C'|
EXTRACTHESID = '2BA7D52F0B80A84EA27EFD69E5D63318'|
EXTRACTHESID = '18A421614FCF65D8F59200E8BF5E885C'|
EXTRACTHESID = '31298DC3DE7F4D03E10621AC531759AD'|
EXTRACTHESID = '347CA70490D1808A598CC8FCC1652FCF'|
EXTRACTHESID = '2A650C34207D921E46460010B6B92885'|
EXTRACTHESID = '085C3754A2DD808F34135804A1C03C1B'|
EXTRACTHESID = '07F702ABD81D666862DBDD7B1FA59D13'|
EXTRACTHESID = '0A724184360BDD9D2E319CEA43AFC9E5'|
EXTRACTHESID = '06E88646B0AB1729DEC2314B856DB2D3'|
EXTRACTHESID = '1A7F8A628D3238F31B940B9E80164AED'|
EXTRACTHESID = '29E72FF78A7911A6A7C562F889881BAF'|
EXTRACTHESID = '0D145729FCE71C2134C6952BA2A4BB39'|
EXTRACTHESID = '0044D2F65FA3C0C34C0588D8F0127F0E'|
EXTRACTHESID = '04F97C73287022EFF77DD3D46EAD1E86'|
EXTRACTHESID = '1D726E0A74589D7B99D984C74993F09E'|
EXTRACTHESID = '064834F1AC713F83832C24006F6F24EF'|
EXTRACTHESID = '1986577590772E0677A6245433E00891'|
EXTRACTHESID = '2F326DD3E28119919A3EB51E78AFFDA7'|
EXTRACTHESID = '3362860BC70A859BF1C2807F34853EC6'|
EXTRACTHESID = '1BF46A914525A5BB42E7A4192C173CB3'|
EXTRACTHESID = '0D74F7D175705B693C15E46E404C8238'|
EXTRACTHESID = '3563A98D9B97FB9BED97A3AC17918ECD'|
EXTRACTHESID = '07B05EC2DD469514527B8E709C2D5F31'|
EXTRACTHESID = '2C8E63C85D1556CB16844900CF178457'|
EXTRACTHESID = '10578361EC71359638E56870FEE40C81'|
EXTRACTHESID = '309AB0F3FA01DE8A0F069AAB87F1127C'|
EXTRACTHESID = '23271DBE8137434FE929EC625B10F491'|
EXTRACTHESID = '07D3B43FA64AE42E3DF5C8542F272F81'|
EXTRACTHESID = '0C613203032095862D917BEED833D700'|
EXTRACTHESID = '13DC7020C7C94108BD5061C5F0106560'|
EXTRACTHESID = '087686C49A6E5AAA42494F23DFE3E01B'|
EXTRACTHESID = '108AFC1AE71EBC1D734B370408774216'|
EXTRACTHESID = '1473EA131D06BAC366574BE2523024D9'|
EXTRACTHESID = '164086AE5C5CE1F6335922D945F19BC9'|
EXTRACTHESID = '0667D8A923761CEB7560AFBA8EA3CCB1'|
EXTRACTHESID = '11519C363C5902AFB5A329D1928FBED4'|
EXTRACTHESID = '32320C0420F80435470144809A06880B'|
EXTRACTHESID = '0D677E2447D9914984D57B02B1D82AA0'|
EXTRACTHESID = '27B3F0E956E5A0A50AE36143E338522F'|
EXTRACTHESID = '23D266FE296397CBA1DB8FB7FE47E51C'|
EXTRACTHESID = '369068444F83EE81C13A04673CF96898'|
EXTRACTHESID = '0992AA45F7BF54AB5DD3750CEE1B8B1E'|
EXTRACTHESID = '09A0F99DE147C160C412B356C639B7B0'|
EXTRACTHESID = '220C2D2FF3DBEF24F4B79C6E1818B6C4'|
EXTRACTHESID = '188431C09BC1E424AA629D67FD3473B4'|
EXTRACTHESID = '0F5144D322F221A22745154754071813'|
EXTRACTHESID = '12F9305115830FEAD486A98B9DE28FE4'|
EXTRACTHESID = '1CF6E91744CA6D039D6DFF672DAC3280'|
EXTRACTHESID = '0F29E7E4D2978D8DD8DCC2D5CFCAE041'|
EXTRACTHESID = '1FA04A17BFC729E034FCCDCF4EE13886'|
EXTRACTHESID = '124843B0500EAFDE03F7B52390ECB321'|
EXTRACTHESID = '0B5DB05E760EE9916D42A4F11578A25B'|
EXTRACTHESID = '0ABA55CB930F4CA9F10CCA97CECB46FB'|
EXTRACTHESID = '02C18719025D0855BA1F20DFE52FA066'|
EXTRACTHESID = '0F6B957FAC7802916DCCD4DAC803655C'|
EXTRACTHESID = '231E6E6C887EAD4381DE9D7753A4E84E'|
EXTRACTHESID = '2DEC89E4FF75993ECDC43C9D67BFFF40'|
EXTRACTHESID = '0AD9662F3932F5F98714D7FEB8D442C9'|
EXTRACTHESID = '24F392818BFFA272E6E186D90020419A'|
EXTRACTHESID = '2110C86A8228A1AEEC40419A9CC70050'|
EXTRACTHESID = '07465CA3B22AE043FE365C0BC4A18DCE'|
EXTRACTHESID = '10D3B58D00715F2F9F3CDB6ACCB39458'|
EXTRACTHESID = '100EF4FAD6C7DF91500E2DAC2E44DF3A'|
EXTRACTHESID = '20110096025B36F1CB62E539FE437153'|
EXTRACTHESID = '319A9DDCDFC65BADCB046E6663230D53'|
EXTRACTHESID = '29EFF541B99B5FF8A12068C7E07EF55C'|
EXTRACTHESID = '298AE775850879ECED4A2FB5E26772AE'|
EXTRACTHESID = '119128C8727AC13F29524E415C738F1D'|
EXTRACTHESID = '2355B86D02546F2C27C310C70C764047'|
EXTRACTHESID = '1A82E27310B54A1E0097BD73A4353860'|
EXTRACTHESID = '2FB302F8C5E0CF5492140B2FBC8F9047'|
EXTRACTHESID = '1AC9BC082795F490C5826762272AA985'|
EXTRACTHESID = '06AECB4B9D9505988A071BCAC4179E2B'|
EXTRACTHESID = '218A5FFADAA44B2197EFEA66DA5D3CD6'|
EXTRACTHESID = '164515677986EB07DB8B1B309CD44CC9'|
EXTRACTHESID = '0A40E0ECEBDCEA6F4D2A05C76FD6EDAF'|
EXTRACTHESID = '26ABA7C9BF12839EDCB62D092A5F59D2'|
EXTRACTHESID = '274005D27F4652BFD4B95F7E0D9287C3'|
EXTRACTHESID = '0B65D94596A4091F88251D9FC48A7139'|
EXTRACTHESID = '1676F3DC6E221205A56325D476B09CC4'|
EXTRACTHESID = '1904A1405E7D458D935E5820D7A810EB'|
EXTRACTHESID = '1F89B87C7A63E410FD27C295E94F2D20'|
EXTRACTHESID = '05E0B9FDDEA1856907C9F3CD8E8FA035'|
EXTRACTHESID = '363E1298A485625628D4FDB304F9E64F'|
EXTRACTHESID = '16EE05E7A98951BF596CDF6BAE717C91'|
EXTRACTHESID = '2BAF296EB2F8FD832B0D9BA69AC99319'|
EXTRACTHESID = '2AF0262A5D98CA470F04F93ED35A8E82'|
EXTRACTHESID = '17F8D1CB5B52B5E3F002BFBDA0C1712C'|
EXTRACTHESID = '2C517C2CC3E90E39A71A58CD1B66D04D'|
EXTRACTHESID = '0DCD6EA61E8A9F70A9E24CDF44CFBB87'|
EXTRACTHESID = '21432F79650FEE3C5412C36F92E6ECA2'|
EXTRACTHESID = '25279D8AC802714B00A6F148D807C818'|
EXTRACTHESID = '12A9CD0026A07F51BF068BFCA2595840'|
EXTRACTHESID = '0D94C25173784412DB2E72428D4AFF25'|
EXTRACTHESID = '1540B093DDDFE4876F4154ED70CC5669'|
EXTRACTHESID = '235FC3332A56E0A2CD938062E33A33E4'|
EXTRACTHESID = '2F616CA89D38FD4A000DD70F1EA40A07'|
EXTRACTHESID = '08235D34E68C3B5273E96DB723058EC9'|
EXTRACTHESID = '1CF796A3599AF5636EA9E606A9F97082'|
EXTRACTHESID = '3508EAEB42EF43EAC093553CB1D95664'|
EXTRACTHESID = '2D60DAF195129696CA0BCFAF9B661191'|
EXTRACTHESID = '10AC2D67784E86ED41B913BC55EBCAF0'|
EXTRACTHESID = '132BADA97BD3F9BE4906DEDDB8E7F5D8'|
```

```
EXTRACTHESID = '216E32BD8CBFD7A301D241C237BB82F5'|
EXTRACTHESID = '1BB2D3EF40F19D8ED476764DB7FE8C4E'|
EXTRACTHESID = '32FA34123C03A490D2C809BF210C7742'|
EXTRACTHESID = '06C9D05F31DF31B907FA7599F945E429'|
EXTRACTHESID =
'13F141E3DDB753F3E72C49F7F7FA0005')HESIDPRESENTNE
W = 1.
EXECUTE.
```

## ERCP Syntax 4 – Admission method type

This syntax was used to update a new variable called ADMISSMETHTYPE that defines how the patient was admitted to hospital for the spell. First of all, the syntax creates a variable called ADMISSMETHTYPE and sets to 0; it then updates this variable dependant on what code is present in ADMIMETH. If ADMIMETH is equal to 11, 12, 13 then it is an ELECTIVE spell and ADMISSMETHTYPE is then updated to code 1. If ADMIMETH is equal to 21, 22, 23, 24, 28 then it is an EMERGENCY spell and ADMISSMETHTYPE is then updated to code 4. A new variable is now created called ADMMETHTYPE which will take the Admission type and the Patient Classification field which looks how the patient was managed into account. The syntax commands if ADMIMETHTYPE is equal to 1 and CLASS PAT is equal to 1 then update ADMMETHTYPE to 1, this means that this is an ELECTIVE ORDINARY admission. The syntax commands if ADMIMETHTYPE is equal to 81 then update ADMMETHTYPE to 1; this means that this is an ELECTIVE ORDINARY admission. The syntax commands if ADMIMETHTYPE is equal to 1 and CLASS PAT is equal to 2 then update ADMMETHTYPE to 2; this means that this is an ELECTIVE DAYCASE admission. The syntax commands if ADMIMETHTYPE is equal to 1 and CLASS PAT is equal to 3 and 4 then update ADMMETHTYPE to 3; this means that this is an ELECTIVE REGULAR ATTENDER admission. The syntax commands if ADMIMETHTYPE is equal to 4 then update ADMMETHTYPE to 4; this means that this is an EMERGENCY admission.

ADMISSMETHTYPE field was then deleted from dataset after this syntax was run as no longer required for analysis and ADMISSMETHTYPE retained.

```
COMPUTE ADMISSMETHTYPE = 0.
EXECUTE.
IF (ADMIMETH = 11|
ADMIMETH = 12|
ADMIMETH = 13)ADMISSMETHTYPE = 1.
EXECUTE.
IF (ADMIMETH = 21|
ADMIMETH = 22|
ADMIMETH = 23|
ADMIMETH = 24|
ADMIMETH = 28)ADMISSMETHTYPE = 4.
EXECUTE.
```

```
COMPUTE ADMMETHTYPE = 0.
EXECUTE.
IF (ADMISSMETHTYPE= 1 &
CLASSPAT = 1) ADMMETHTYPE = 1.
EXECUTE.
IF (ADMIMETH = 81)ADMMETHTYPE = 1.
EXECUTE.
IF (ADMISSMETHTYPE= 1 &
CLASSPAT = 2) ADMMETHTYPE = 2.
EXECUTE.
IF (ADMISSMETHTYPE= 1 &
CLASSPAT = 3) ADMMETHTYPE = 3.
EXECUTE.
IF (ADMISSMETHTYPE= 1 &
CLASSPAT = 4) ADMMETHTYPE = 3.
EXECUTE.
IF (ADMISSMETHTYPE= 4) ADMMETHTYPE = 4.
EXECUTE.
```

### ERCP Syntax 5 – ERCP occurring before admission date

```
COMPUTE ERCPDATEB4ADMDATE = 0.
EXECUTE.
IF (ERCPDATE1 < ADMIDATE2)ERCPDATEB4ADMDATE = 1.
EXECUTE.
```

### ERCP Syntax 6 – Dataset month of ERCP

```
COMPUTE MOE = 0.
EXECUTE.
IF (MONTHOFERCP = 4)MOE = 1.
EXECUTE.
IF (MONTHOFERCP = 5)MOE = 2.
EXECUTE.
IF (MONTHOFERCP = 6)MOE = 3.
EXECUTE.
IF (MONTHOFERCP = 7)MOE = 4.
EXECUTE.
IF (MONTHOFERCP = 8)MOE = 5.
EXECUTE.
IF (MONTHOFERCP = 9)MOE = 6.
EXECUTE.
IF (MONTHOFERCP = 10)MOE = 7.
EXECUTE.
IF (MONTHOFERCP = 11)MOE = 8.
EXECUTE.
IF (MONTHOFERCP = 12)MOE = 9.
EXECUTE.
IF (MONTHOFERCP = 1)MOE = 10.
EXECUTE.
IF (MONTHOFERCP = 2)MOE = 11.
EXECUTE.
IF (MONTHOFERCP = 3)MOE = 12.
EXECUTE.
```

## ERCP Syntax 7 – Assign 2 year dataset month

```
COMPUTE MONTHNUM = 0.
EXECUTE.
IF (MONTHOFERCP = 1 & DATAYEAR = 200607)MONTHNUM = 1.
EXECUTE.
IF (MONTHOFERCP = 2 & DATAYEAR = 200607)MONTHNUM = 2.
EXECUTE.
IF (MONTHOFERCP = 3 & DATAYEAR = 200607)MONTHNUM = 3.
EXECUTE.
IF (MONTHOFERCP = 4 & DATAYEAR = 200607)MONTHNUM = 4.
EXECUTE.
IF (MONTHOFERCP = 5 & DATAYEAR = 200607)MONTHNUM = 5.
EXECUTE.
IF (MONTHOFERCP = 6 & DATAYEAR = 200607)MONTHNUM = 6.
EXECUTE.
IF (MONTHOFERCP = 7 & DATAYEAR = 200607)MONTHNUM = 7.
EXECUTE.
IF (MONTHOFERCP = 8 & DATAYEAR = 200607)MONTHNUM = 8.
EXECUTE.
IF (MONTHOFERCP = 9 & DATAYEAR = 200607)MONTHNUM = 9.
EXECUTE.
IF (MONTHOFERCP = 10 & DATAYEAR = 200607)MONTHNUM = 10.
EXECUTE.
IF (MONTHOFERCP = 11 & DATAYEAR = 200607)MONTHNUM = 11.
EXECUTE.
IF (MONTHOFERCP = 12 & DATAYEAR = 200607)MONTHNUM = 12.
EXECUTE.
IF (MONTHOFERCP = 1 & DATAYEAR = 200708)MONTHNUM = 13.
EXECUTE.
IF (MONTHOFERCP = 2 & DATAYEAR = 200708)MONTHNUM = 14.
EXECUTE.
IF (MONTHOFERCP = 3 & DATAYEAR = 200708)MONTHNUM = 15.
EXECUTE.
IF (MONTHOFERCP = 4 & DATAYEAR = 200708)MONTHNUM = 16.
EXECUTE.
IF (MONTHOFERCP = 5 & DATAYEAR = 200708)MONTHNUM = 17.
EXECUTE.
IF (MONTHOFERCP = 6 & DATAYEAR = 200708)MONTHNUM = 18.
EXECUTE.
IF (MONTHOFERCP = 7 & DATAYEAR = 200708)MONTHNUM = 19.
EXECUTE.
IF (MONTHOFERCP = 8 & DATAYEAR = 200708)MONTHNUM = 20.
EXECUTE.
IF (MONTHOFERCP = 9 & DATAYEAR = 200708)MONTHNUM = 21.
EXECUTE.
IF (MONTHOFERCP = 10 & DATAYEAR = 200708)MONTHNUM = 22.
EXECUTE.
IF (MONTHOFERCP = 11 & DATAYEAR = 200708)MONTHNUM = 23.
EXECUTE.
IF (MONTHOFERCP = 12 & DATAYEAR = 200708)MONTHNUM = 24.
EXECUTE.
```

## ERCP Syntax 8 – Speciality type

```
COMPUTE SPECIALTYTYPE = 0.
EXECUTE.
IF (MAINSPEF = 300|
MAINSPEF = 301|
MAINSPEF = 302|
MAINSPEF = 303|
MAINSPEF = 305|
MAINSPEF = 313|
MAINSPEF = 314|
MAINSPEF = 315|
MAINSPEF = 320|
MAINSPEF = 330|
MAINSPEF = 340|
MAINSPEF = 350|
MAINSPEF = 352|
MAINSPEF = 360|
MAINSPEF = 361|
MAINSPEF = 370|
MAINSPEF = 400|
MAINSPEF = 410|
MAINSPEF = 430|
MAINSPEF = 823)SPECIALTYTYPE = 2.
EXECUTE.
```

```
IF (MAINSPEF = 100|
MAINSPEF = 101|
MAINSPEF = 110|
MAINSPEF = 120|
MAINSPEF = 130|
MAINSPEF = 140|
MAINSPEF = 145|
MAINSPEF = 150|
MAINSPEF = 160|
MAINSPEF = 170|
MAINSPEF = 180|
MAINSPEF = 190|
MAINSPEF = 192)SPECIALTYTYPE = 1.
EXECUTE.
```

## ERCP Syntax 9 – Age bands

```
COMPUTE AGEBAND = 0.
EXECUTE.
IF (ENDAGE < 21) AGEBAND = 16.
EXECUTE.
IF (ENDAGE < 26 & ENDAGE >20) AGEBAND =
21.
EXECUTE.
IF (ENDAGE < 31 & ENDAGE >25) AGEBAND =
26.
EXECUTE.
IF (ENDAGE < 36 & ENDAGE >30) AGEBAND =
31.
EXECUTE.
IF (ENDAGE < 41 & ENDAGE >35) AGEBAND =
36.
EXECUTE.
IF (ENDAGE < 46 & ENDAGE >40) AGEBAND =
41.
EXECUTE.
IF (ENDAGE < 51 & ENDAGE >45) AGEBAND =
46.
EXECUTE.
IF (ENDAGE < 56 & ENDAGE >50) AGEBAND =
51.
EXECUTE.
IF (ENDAGE < 61 & ENDAGE >55) AGEBAND =
56.
EXECUTE.
IF (ENDAGE < 66 & ENDAGE >60) AGEBAND =
61.
EXECUTE.
IF (ENDAGE < 71 & ENDAGE >65) AGEBAND =
66.
EXECUTE.
IF (ENDAGE < 76 & ENDAGE >70) AGEBAND =
71.
EXECUTE.
IF (ENDAGE < 81 & ENDAGE >75) AGEBAND =
76.
EXECUTE.
IF (ENDAGE < 86 & ENDAGE >80) AGEBAND =
81.
EXECUTE.
IF (ENDAGE > 85) AGEBAND = 86.
EXECUTE.
```

## ERCP Syntax 10 – Age groups

```
COMPUTE AGEGROUP = 0.
EXECUTE.
IF (ENDAGE < 55) AGEGROUP = 1.
EXECUTE.
IF (ENDAGE > 54 & ENDAGE < 65) AGEGROUP = 2.
EXECUTE.
IF (ENDAGE > 64 & ENDAGE <75) AGEGROUP = 3.
EXECUTE.
IF (ENDAGE >74 & ENDAGE <85) AGEGROUP = 4.
EXECUTE.
IF (ENDAGE >84) AGEGROUP = 5.
EXECUTE.
```

**ERCP Syntax 11 – Death marker**

```
COMPUTE DEATHMARKERALL = 0.
EXECUTE.
IF (DIEDCATEGORY > 0)DEATHMARKERALL = 1.
EXECUTE.
```

**ERCP Syntax 12 – Died in hospital**

```
COMPUTE DIEDINHOSPITAL = 0.
EXECUTE.
IF (DISMETH = 4)DIEDINHOSPITAL = 1.
EXECUTE.
```

**ERCP Syntax 13 – Death categories**

(Alive, death within 7 days, death within 8 to 30 days, death beyond 30 days)

```
COMPUTE DIEDCATEGORY = 0.
EXECUTE.
IF (DODMINUSERCPDATE > 30)DIEDCATEGORY = 3.
EXECUTE.
IF (DODMINUSERCPDATE > 7 & DODMINUSERCPDATE < 31)DIEDCATEGORY = 2.
EXECUTE.
IF (DODMINUSERCPDATE < 8)DIEDCATEGORY = 1.
EXECUTE.
```

**ERCP Syntax 14 – Mortality markers (7 and 30 day)**

```
COMPUTE DEATH7 = 0.
EXECUTE.
IF (DODMINUSERCPDATE1 < 8)DEATH7 = 1.
EXECUTE.
COMPUTE DEATH30 = 0.
EXECUTE.
IF (DODMINUSERCPDATE1 < 31)DEATH30 = 1.
EXECUTE.
```

## ERCP Syntax 15 – Comorbidity

```
COMPUTE ALLCOMORB1 = 0.
EXECUTE.
IF (DIAG01 = 'C000'| DIAG01 = 'C001'| DIAG01 = 'C002'| DIAG01 = 'C003'| DIAG01 = 'C004'| DIAG01 = 'C005'| DIAG01 = 'C006'| DIAG01 = 'C008'| DIAG01 = 'C009'| DIAG01 = 'C01X'| DIAG01 = 'C020'| DIAG01 = 'C021'| DIAG01 = 'C022'| DIAG01 = 'C023'| DIAG01 = 'C024'| DIAG01 = 'C028'| DIAG01 = 'C029'| DIAG01 = 'C030'| DIAG01 = 'C031'| DIAG01 = 'C039'| DIAG01 = 'C040'| DIAG01 = 'C041'| DIAG01 = 'C048'| DIAG01 = 'C049'| DIAG01 = 'C050'| DIAG01 = 'C051'| DIAG01 = 'C052'| DIAG01 = 'C058'| DIAG01 = 'C059'| DIAG01 = 'C060'| DIAG01 = 'C061'| DIAG01 = 'C062'| DIAG01 = 'C068'| DIAG01 = 'C069'| DIAG01 = 'C07X'| DIAG01 = 'C080'| DIAG01 = 'C081'| DIAG01 = 'C088'| DIAG01 = 'C089'| DIAG01 = 'C090'| DIAG01 = 'C091'| DIAG01 = 'C098'| DIAG01 = 'C099'| DIAG01 = 'C100'| DIAG01 = 'C101'| DIAG01 = 'C102'| DIAG01 = 'C103'| DIAG01 = 'C104'| DIAG01 = 'C108'| DIAG01 = 'C109'| DIAG01 = 'C110'| DIAG01 = 'C111'| DIAG01 = 'C112'| DIAG01 = 'C113'| DIAG01 = 'C118'| DIAG01 = 'C119'| DIAG01 = 'C12X'| DIAG01 = 'C130'| DIAG01 = 'C131'| DIAG01 = 'C132'| DIAG01 = 'C138'| DIAG01 = 'C139'| DIAG01 = 'C140'| DIAG01 = 'C142'| DIAG01 = 'C148'| DIAG01 = 'C150'| DIAG01 = 'C151'| DIAG01 = 'C152'| DIAG01 = 'C153'| DIAG01 = 'C154'| DIAG01 = 'C155'| DIAG01 = 'C158'| DIAG01 = 'C159'| DIAG01 = 'C160'| DIAG01 = 'C161'| DIAG01 = 'C162'| DIAG01 = 'C163'| DIAG01 = 'C164'| DIAG01 = 'C165'| DIAG01 = 'C166'| DIAG01 = 'C168'| DIAG01 = 'C169'| DIAG01 = 'C170'| DIAG01 = 'C171'| DIAG01 = 'C172'| DIAG01 = 'C173'| DIAG01 = 'C178'| DIAG01 = 'C179'| DIAG01 = 'C180'| DIAG01 = 'C181'| DIAG01 = 'C182'| DIAG01 = 'C183'| DIAG01 = 'C184'| DIAG01 = 'C185'| DIAG01 = 'C186'| DIAG01 = 'C187'| DIAG01 = 'C188'| DIAG01 = 'C189'| DIAG01 = 'C19X'| DIAG01 = 'C20X'| DIAG01 = 'C210'| DIAG01 = 'C211'| DIAG01 = 'C212'| DIAG01 = 'C218'| DIAG01 = 'C220'| DIAG01 = 'C221'| DIAG01 = 'C222'| DIAG01 = 'C223'| DIAG01 = 'C224'| DIAG01 = 'C227'| DIAG01 = 'C229'| DIAG01 = 'C23X'| DIAG01 = 'C240'| DIAG01 = 'C241'| DIAG01 = 'C248'| DIAG01 = 'C249'| DIAG01 = 'C250'| DIAG01 = 'C251'| DIAG01 = 'C252'| DIAG01 = 'C253'| DIAG01 = 'C254'| DIAG01 = 'C257'| DIAG01 = 'C258'| DIAG01 = 'C259'| DIAG01 = 'C260'| DIAG01 = 'C261'| DIAG01 = 'C268'| DIAG01 = 'C269'| DIAG01 = 'C300'| DIAG01 = 'C301'| DIAG01 = 'C310'| DIAG01 = 'C311'| DIAG01 = 'C312'| DIAG01 = 'C313'| DIAG01 = 'C318'| DIAG01 = 'C319'| DIAG01 = 'C320'| DIAG01 = 'C321'| DIAG01 = 'C322'| DIAG01 = 'C323'| DIAG01 = 'C328'| DIAG01 = 'C329'| DIAG01 = 'C33X'| DIAG01 = 'C340'| DIAG01 = 'C341'| DIAG01 = 'C342'| DIAG01 = 'C343'| DIAG01 = 'C348'| DIAG01 = 'C349'| DIAG01 = 'C37X'| DIAG01 = 'C380'| DIAG01 = 'C381'| DIAG01 = 'C382'| DIAG01 = 'C383'| DIAG01 = 'C384'| DIAG01 = 'C388'| DIAG01 = 'C390'| DIAG01 = 'C398'| DIAG01 = 'C399'| DIAG01 = 'C400'| DIAG01 = 'C401'| DIAG01 = 'C402'| DIAG01 = 'C403'| DIAG01 = 'C408'| DIAG01 = 'C409'| DIAG01 = 'C410'| DIAG01 = 'C411'| DIAG01 = 'C412'| DIAG01 = 'C413'| DIAG01 = 'C414'| DIAG01 = 'C418'| DIAG01 = 'C419'| DIAG01 = 'C430'| DIAG01 = 'C431'| DIAG01 = 'C432'| DIAG01 = 'C433'| DIAG01 = 'C434'| DIAG01 = 'C435'| DIAG01 = 'C436'| DIAG01 = 'C437'| DIAG01 = 'C438'| DIAG01 = 'C439'| DIAG01 = 'C450'| DIAG01 = 'C451'| DIAG01 = 'C452'| DIAG01 = 'C457'| DIAG01 = 'C459'| DIAG01 = 'C460'| DIAG01 = 'C461'| DIAG01 = 'C462'| DIAG01 = 'C463'| DIAG01 = 'C467'| DIAG01 = 'C468'| DIAG01 = 'C469'| DIAG01 = 'C470'| DIAG01 = 'C471'| DIAG01 = 'C472'| DIAG01 = 'C473'| DIAG01 = 'C474'| DIAG01 = 'C475'| DIAG01 = 'C476'| DIAG01 = 'C478'| DIAG01 = 'C479'| DIAG01 = 'C480'| DIAG01 = 'C481'| DIAG01 = 'C482'| DIAG01 = 'C488'| DIAG01 = 'C490'| DIAG01 = 'C491'|
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## ERCP Syntax 16 – Cancer marker (Based on Dr Foster list)

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EXECUTE.

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EXECUTE.

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EXECUTE.

And then repeat for

DIAG03 to DIAG17

## ERCP Syntax 17 – Non cancer comorbidity

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DIAG01 = 'K767'|
DIAG01 = 'K768'|
DIAG01 = 'E102'|
DIAG01 = 'E103'|
DIAG01 = 'E104'|
DIAG01 = 'E105'|
DIAG01 = 'E106'|
DIAG01 = 'E107'|
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DIAG01 = 'G811'|
DIAG01 = 'G819'|
DIAG01 = 'G820'|
DIAG01 = 'G821'|
DIAG01 = 'G822'|
DIAG01 = 'N001'|
DIAG01 = 'N002'|
DIAG01 = 'N003'|
DIAG01 = 'N004'|
DIAG01 = 'N005'|
DIAG01 = 'N007'|
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DIAG01 = 'N074'|
DIAG01 = 'N075'|
DIAG01 = 'N180'|
DIAG01 = 'N188'|
DIAG01 = 'N189'|
DIAG01 = 'N19X'|
DIAG01 = 'N250'|
DIAG01 = 'Z992'|
DIAG01 = 'B200'|
DIAG01 = 'B201'|
DIAG01 = 'B202'|
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DIAG01 = 'B213'|
DIAG01 = 'B217'|
DIAG01 = 'B218'|
DIAG01 = 'B219'|
DIAG01 = 'B220'|
DIAG01 = 'B221'|
DIAG01 = 'B222'|
DIAG01 = 'B227'|
DIAG01 = 'B230'|
DIAG01 = 'B231'|
DIAG01 = 'B232'|
DIAG01 = 'B238'|

```
DIAG01 =
'B24X')NONCANCERCOM
ORB1 = 1.
EXECUTE.

COMPUTE
NONCANCERCOMORB2 =
0.
EXECUTE.
IF (DIAG02 = 'I210'|
DIAG02 = 'I211'|
DIAG02 = 'I212'|
DIAG02 = 'I213'|
DIAG02 = 'I214'|
DIAG02 = 'I219'|
DIAG02 = 'I220'|
DIAG02 = 'I221'|
DIAG02 = 'I228'|
DIAG02 = 'I229'|
DIAG02 = 'I252'|
DIAG02 = 'I500'|
DIAG02 = 'I710'|
DIAG02 = 'I711'|
DIAG02 = 'I712'|
DIAG02 = 'I713'|
DIAG02 = 'I714'|
DIAG02 = 'I715'|
DIAG02 = 'I716'|
DIAG02 = 'I718'|
DIAG02 = 'I719'|
DIAG02 = 'I738'|
DIAG02 = 'I739'|
DIAG02 = 'I600'|
DIAG02 = 'I601'|
DIAG02 = 'I602'|
DIAG02 = 'I603'|
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DIAG02 = 'I614'|
DIAG02 = 'I615'|
DIAG02 = 'I616'|
DIAG02 = 'I618'|
DIAG02 = 'I619'|
DIAG02 = 'I620'|
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DIAG02 = 'I631'|
DIAG02 = 'I632'|
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DIAG02 = 'I634'|
DIAG02 = 'I635'|
DIAG02 = 'I636'|
DIAG02 = 'I638'|
DIAG02 = 'I639'|
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DIAG02 = 'I652'|
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DIAG02 = 'I669'|
DIAG02 = 'I670'|
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DIAG02 = 'I674'|
DIAG02 = 'I675'|
DIAG02 = 'I676'|
DIAG02 = 'I677'|
DIAG02 = 'I678'|
DIAG02 = 'I679'|
DIAG02 = 'I680'|
DIAG02 = 'I681'|
DIAG02 = 'I682'|
DIAG02 = 'I688'|
DIAG02 = 'I690'|
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DIAG02 = 'F024'|
DIAG02 = 'F028'|
DIAG02 = 'F03X'|
DIAG02 = 'F051'|
DIAG02 = 'J40X'|
DIAG02 = 'J410'|
DIAG02 = 'J411'|
DIAG02 = 'J418'|
DIAG02 = 'J42X'|
DIAG02 = 'J430'|
DIAG02 = 'J431'|
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DIAG02 = 'J450'|
DIAG02 = 'J451'|
DIAG02 = 'J458'|
DIAG02 = 'J459'|
DIAG02 = 'J46X'|
DIAG02 = 'J47X'|
DIAG02 = 'J60X'|
DIAG02 = 'J61X'|
DIAG02 = 'J620'|
DIAG02 = 'J628'|
DIAG02 = 'J630'|
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DIAG02 = 'J633'|
DIAG02 = 'J634'|
DIAG02 = 'J635'|
DIAG02 = 'J638'|
DIAG02 = 'J64X'|
DIAG02 = 'J65X'|
DIAG02 = 'J660'|
DIAG02 = 'J661'|
DIAG02 = 'J662'|
DIAG02 = 'J668'|
DIAG02 = 'J670'|
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DIAG02 = 'K714'|
DIAG02 = 'K715'|
DIAG02 = 'K716'|
DIAG02 = 'K717'|
DIAG02 = 'K718'|
```

```
DIAG02 = 'K719'|
DIAG02 = 'K721'|
DIAG02 = 'K729'|
DIAG02 = 'K730'|
DIAG02 = 'K731'|
DIAG02 = 'K732'|
DIAG02 = 'K738'|
DIAG02 = 'K739'|
DIAG02 = 'K740'|
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DIAG02 = 'K743'|
DIAG02 = 'K744'|
DIAG02 = 'K745'|
DIAG02 = 'K746'|
DIAG02 = 'K753'|
DIAG02 = 'K754'|
DIAG02 = 'K758'|
DIAG02 = 'K764'|
DIAG02 = 'K765'|
DIAG02 = 'K766'|
DIAG02 = 'K767'|
DIAG02 = 'K768'|
DIAG02 = 'E102'|
DIAG02 = 'E103'|
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DIAG02 = 'G811'|
DIAG02 = 'G819'|
DIAG02 = 'G820'|
DIAG02 = 'G821'|
DIAG02 = 'G822'|
DIAG02 = 'N001'|
DIAG02 = 'N002'|
DIAG02 = 'N003'|
DIAG02 = 'N004'|
DIAG02 = 'N005'|
DIAG02 = 'N007'|
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DIAG02 = 'N074'|
DIAG02 = 'N075'|
DIAG02 = 'N180'|
DIAG02 = 'N188'|
DIAG02 = 'N189'|
DIAG02 = 'N19X'|
DIAG02 = 'N250'|
DIAG02 = 'Z992'|
DIAG02 = 'B200'|
DIAG02 = 'B201'|
DIAG02 = 'B202'|
DIAG02 = 'B203'|
DIAG02 = 'B204'|
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DIAG02 = 'B211'|
DIAG02 = 'B212'|
DIAG02 = 'B213'|
DIAG02 = 'B217'|
DIAG02 = 'B218'|
DIAG02 = 'B219'|
DIAG02 = 'B220'|
DIAG02 = 'B221'|
DIAG02 = 'B222'|
DIAG02 = 'B227'|
DIAG02 = 'B230'|
DIAG02 = 'B231'|
DIAG02 = 'B232'|
DIAG02 = 'B238'|
DIAG02 =
'B24X')NONCANCERCOM
ORB2 = 1.
EXECUTE.
```

And then repeat for DIAG03 to DIAG17

## ERCP Syntax 18 – Gallstones

```
COMPUTE GS1 = 0.
EXECUTE.
IF (DIAG01 = 'K800'|
DIAG01 = 'K801'|
DIAG01 = 'K802'|
DIAG01 = 'K803'|
DIAG01 = 'K804'|
DIAG01 = 'K805'|
DIAG01 = 'K808'|
DIAG01 = 'K563')GS1 = 1.
EXECUTE.
COMPUTE GS2 = 0.
EXECUTE.
IF (DIAG02 = 'K800'|
DIAG02 = 'K801'|
DIAG02 = 'K802'|
DIAG02 = 'K803'|
DIAG02 = 'K804'|
DIAG02 = 'K805'|
DIAG02 = 'K808'|
DIAG02 = 'K563')GS2 = 1.
EXECUTE.
COMPUTE GS3 = 0.
EXECUTE.
IF (DIAG03 = 'K800'|
DIAG03 = 'K801'|
DIAG03 = 'K802'|
```

```
DIAG03 = 'K803'|
DIAG03 = 'K804'|
DIAG03 = 'K805'|
DIAG03 = 'K808'|
DIAG03 = 'K563')GS3 = 1.
EXECUTE.
COMPUTE GS4 = 0.
EXECUTE.
IF (DIAG04 = 'K800'|
DIAG04 = 'K801'|
DIAG04 = 'K802'|
DIAG04 = 'K803'|
DIAG04 = 'K804'|
DIAG04 = 'K805'|
DIAG04 = 'K808'|
DIAG04 = 'K563')GS4 = 1.
EXECUTE.
COMPUTE GS5 = 0.
EXECUTE.
IF (DIAG05 = 'K800'|
DIAG05 = 'K801'|
DIAG05 = 'K802'|
DIAG05 = 'K803'|
DIAG05 = 'K804'|
DIAG05 = 'K805'|
DIAG05 = 'K808'|
DIAG05 = 'K563')GS5 = 1.
EXECUTE.
COMPUTE GS6 = 0.
EXECUTE.
IF (DIAG06 = 'K800'|
DIAG06 = 'K801'|
DIAG06 = 'K802'|
DIAG06 = 'K803'|
DIAG06 = 'K804'|
DIAG06 = 'K805'|
DIAG06 = 'K808'|
DIAG06 = 'K563')GS6 = 1.
EXECUTE.
COMPUTE GS7 = 0.
EXECUTE.
IF (DIAG07 = 'K800'|
DIAG07 = 'K801'|
DIAG07 = 'K802'|
DIAG07 = 'K803'|
DIAG07 = 'K804'|
DIAG07 = 'K805'|
DIAG07 = 'K808'|
DIAG07 = 'K563')GS7 = 1.
EXECUTE.
COMPUTE GS8 = 0.
EXECUTE.
IF (DIAG08 = 'K800'|
DIAG08 = 'K801'|
DIAG08 = 'K802'|
DIAG08 = 'K803'|
DIAG08 = 'K804'|
DIAG08 = 'K805'|
DIAG08 = 'K808'|
DIAG08 = 'K563')GS8 = 1.
EXECUTE.
COMPUTE GS9 = 0.
EXECUTE.
IF (DIAG09 = 'K800'|
DIAG09 = 'K801'|
DIAG09 = 'K802'|
DIAG09 = 'K803'|
DIAG09 = 'K804'|
DIAG09 = 'K805'|
DIAG09 = 'K808'|
DIAG09 = 'K563')GS9 = 1.
EXECUTE.
COMPUTE GS10 = 0.
EXECUTE.
IF (DIAG10 = 'K800'|
DIAG10 = 'K801'|
DIAG10 = 'K802'|
DIAG10 = 'K803'|
DIAG10 = 'K804'|
DIAG10 = 'K805'|
DIAG10 = 'K808'|
DIAG10 = 'K563')GS10 = 1.
EXECUTE.
COMPUTE GS11 = 0.
EXECUTE.
IF (DIAG11 = 'K800'|
DIAG11 = 'K801'|
DIAG11 = 'K802'|
DIAG11 = 'K803'|
DIAG11 = 'K804'|
DIAG11 = 'K805'|
DIAG11 = 'K808'|
DIAG11 = 'K563')GS11 = 1.
EXECUTE.
COMPUTE GS12 = 0.
EXECUTE.
IF (DIAG12 = 'K800'|
DIAG12 = 'K801'|
DIAG12 = 'K802'|
DIAG12 = 'K803'|
DIAG12 = 'K804'|
DIAG12 = 'K805'|
DIAG12 = 'K808'|
DIAG12 = 'K563')GS12 = 1.
EXECUTE.
COMPUTE GS13 = 0.
EXECUTE.
IF (DIAG13 = 'K800'|
DIAG13 = 'K801'|
DIAG13 = 'K802'|
DIAG13 = 'K803'|
DIAG13 = 'K804'|
DIAG13 = 'K805'|
DIAG13 = 'K808'|
DIAG13 = 'K563')GS13 = 1.
EXECUTE.
COMPUTE GS14 = 0.
EXECUTE.
IF (DIAG14 = 'K800'|
DIAG14 = 'K801'|
DIAG14 = 'K802'|
DIAG14 = 'K803'|
DIAG14 = 'K804'|
DIAG14 = 'K805'|
DIAG14 = 'K808'|
DIAG14 = 'K563')GS14 = 1.
EXECUTE.
```

## ERCP Syntax 19 – Acute pancreatitis

```
COMPUTE PANC1 = 0.

EXECUTE.
IF (DIAG01 = 'K85X')PANC1 =
1.
EXECUTE.
COMPUTE PANC2 = 0.
EXECUTE.
IF (DIAG02 = 'K85X')PANC2 =
1.
EXECUTE.
COMPUTE PANC3 = 0.
EXECUTE.
IF (DIAG03 = 'K85X')PANC3 =
1.
EXECUTE.
COMPUTE PANC4 = 0.
EXECUTE.
IF (DIAG04 = 'K85X')PANC4 =
1.
EXECUTE.
COMPUTE PANC5 = 0.
EXECUTE.
IF (DIAG05 = 'K85X')PANC5 =
1.
EXECUTE.
COMPUTE PANC6 = 0.
EXECUTE.
IF (DIAG06 = 'K85X')PANC6 =
1.
EXECUTE.
COMPUTE PANC7 = 0.
EXECUTE.
IF (DIAG07 = 'K85X')PANC7 =
1.
EXECUTE.
COMPUTE PANC8 = 0.
EXECUTE.
IF (DIAG08 = 'K85X')PANC8 =
1.
EXECUTE.
COMPUTE PANC9 = 0.
EXECUTE.
IF (DIAG09 = 'K85X')PANC9 =
1.
EXECUTE.
COMPUTE PANC10 = 0.
EXECUTE.
IF (DIAG10 = 'K85X')PANC10
= 1.
EXECUTE.
COMPUTE PANC11 = 0.
EXECUTE.
IF (DIAG11 = 'K85X')PANC11
= 1.
EXECUTE.
COMPUTE PANC12 = 0.
EXECUTE.
IF (DIAG12 = 'K85X')PANC12
= 1.
EXECUTE.
COMPUTE PANC13 = 0.
EXECUTE.
IF (DIAG13 = 'K85X')PANC13
= 1.
EXECUTE.
COMPUTE PANC14 = 0.
EXECUTE.
IF (DIAG14 = 'K85X')PANC14
= 1.
EXECUTE.
```

## ERCP Syntax 20 – Hepato-pancreatico-biliary cancer diagnosis

```
COMPUTE HPBCA1 = 0.
EXECUTE.
IF (DIAG01 = 'C220'|
DIAG01 = 'C221'|
DIAG01 = 'C222'|
DIAG01 = 'C223'|
DIAG01 = 'C224'|
DIAG01 = 'C227'|
DIAG01 = 'C229'|
DIAG01 = 'C23X'|
DIAG01 = 'C240'|
DIAG01 = 'C241'|
DIAG01 = 'C248'|
DIAG01 = 'C249'|
DIAG01 = 'C250'|
DIAG01 = 'C251'|
DIAG01 = 'C252'|
DIAG01 = 'C253'|
DIAG01 = 'C254'|
DIAG01 = 'C257'|
DIAG01 = 'C258'|
DIAG01 = 'C259'|
DIAG01 = 'C787'|
DIAG01 =
'D376')HPBCA1 = 1.
EXECUTE.

COMPUTE HPBCA2 = 0.
EXECUTE.
IF (DIAG02 = 'C220'|
DIAG02 = 'C221'|
DIAG02 = 'C222'|
DIAG02 = 'C223'|
DIAG02 = 'C224'|
DIAG02 = 'C227'|
DIAG02 = 'C229'|
DIAG02 = 'C23X'|
DIAG02 = 'C240'|
DIAG02 = 'C241'|
DIAG02 = 'C248'|
DIAG02 = 'C249'|
DIAG02 = 'C250'|
DIAG02 = 'C251'|
DIAG02 = 'C252'|
DIAG02 = 'C253'|
DIAG02 = 'C254'|
DIAG02 = 'C257'|
DIAG02 = 'C258'|
DIAG02 = 'C259'|
DIAG02 = 'C787'|
DIAG02 =
'C376')HPBCA2 = 1.
EXECUTE.

COMPUTE HPBCA3 = 0.
EXECUTE.
IF (DIAG03 = 'C220'|
DIAG03 = 'C221'|
DIAG03 = 'C222'|
DIAG03 = 'C223'|
DIAG03 = 'C224'|
DIAG03 = 'C227'|
DIAG03 = 'C229'|
DIAG03 = 'C23X'|
DIAG03 = 'C240'|
DIAG03 = 'C241'|
DIAG03 = 'C248'|
DIAG03 = 'C249'|
DIAG03 = 'C250'|
DIAG03 = 'C251'|
DIAG03 = 'C252'|
DIAG03 = 'C253'|
DIAG03 = 'C254'|
DIAG03 = 'C257'|
DIAG03 = 'C258'|
DIAG03 = 'C259'|
DIAG03 = 'C787'|
DIAG03 =
'C376')HPBCA3 = 1.
EXECUTE.

COMPUTE HPBCA4 = 0.
EXECUTE.
IF (DIAG04 = 'C220'|
DIAG04 = 'C221'|
DIAG04 = 'C222'|
DIAG04 = 'C223'|
DIAG04 = 'C224'|
DIAG04 = 'C227'|
DIAG04 = 'C229'|
DIAG04 = 'C23X'|
DIAG04 = 'C240'|
DIAG04 = 'C241'|
DIAG04 = 'C248'|
DIAG04 = 'C249'|
DIAG04 = 'C250'|
DIAG04 = 'C251'|
DIAG04 = 'C252'|
DIAG04 = 'C253'|
DIAG04 = 'C254'|
DIAG04 = 'C257'|
DIAG04 = 'C258'|
DIAG04 = 'C259'|
DIAG04 = 'C787'|
DIAG04 =
'C376')HPBCA4 = 1.
EXECUTE.

COMPUTE HPBCA5 = 0.
EXECUTE.
IF (DIAG05 = 'C220'|
DIAG05 = 'C221'|
DIAG05 = 'C222'|
DIAG05 = 'C223'|
DIAG05 = 'C224'|
DIAG05 = 'C227'|
DIAG05 = 'C229'|
DIAG05 = 'C23X'|
DIAG05 = 'C240'|
DIAG05 = 'C241'|
DIAG05 = 'C248'|
DIAG05 = 'C249'|
DIAG05 = 'C250'|
DIAG05 = 'C251'|
DIAG05 = 'C252'|
DIAG05 = 'C253'|
DIAG05 = 'C254'|
DIAG05 = 'C257'|
DIAG05 = 'C258'|
DIAG05 = 'C259'|
DIAG05 = 'C787'|
DIAG05 =
'C376')HPBCA5 = 1.
EXECUTE.

COMPUTE HPBCA6 = 0.
EXECUTE.
IF (DIAG06 = 'C220'|
DIAG06 = 'C221'|
DIAG06 = 'C222'|
DIAG06 = 'C223'|
DIAG06 = 'C224'|
DIAG06 = 'C227'|
DIAG06 = 'C229'|
DIAG06 = 'C23X'|
DIAG06 = 'C240'|
DIAG06 = 'C241'|
DIAG06 = 'C248'|
DIAG06 = 'C249'|
DIAG06 = 'C250'|
DIAG06 = 'C251'|
DIAG06 = 'C252'|
DIAG06 = 'C253'|
DIAG06 = 'C254'|
DIAG06 = 'C257'|
DIAG06 = 'C258'|
DIAG06 = 'C259'|
DIAG06 = 'C787'|
DIAG06 =
'C376')HPBCA6 = 1.
EXECUTE.

COMPUTE HPBCA7 = 0.
EXECUTE.
IF (DIAG07 = 'C220'|
DIAG07 = 'C221'|
DIAG07 = 'C222'|
DIAG07 = 'C223'|
DIAG07 = 'C224'|
DIAG07 = 'C227'|
DIAG07 = 'C229'|
DIAG07 = 'C23X'|
DIAG07 = 'C240'|
DIAG07 = 'C241'|
DIAG07 = 'C248'|
DIAG07 = 'C249'|
DIAG07 = 'C250'|
DIAG07 = 'C251'|
DIAG07 = 'C252'|
DIAG07 = 'C253'|
DIAG07 = 'C254'|
DIAG07 = 'C257'|
DIAG07 = 'C258'|
DIAG07 = 'C259'|
DIAG07 = 'C787'|
DIAG07 =
'C376')HPBCA7 = 1.
EXECUTE.

COMPUTE HPBCA8 = 0.
EXECUTE.
IF (DIAG08 = 'C220'|
DIAG08 = 'C221'|
DIAG08 = 'C222'|
DIAG08 = 'C223'|
DIAG08 = 'C224'|
DIAG08 = 'C227'|
DIAG08 = 'C229'|
DIAG08 = 'C23X'|
DIAG08 = 'C240'|
DIAG08 = 'C241'|
DIAG08 = 'C248'|
DIAG08 = 'C249'|
DIAG08 = 'C250'|
DIAG08 = 'C251'|
DIAG08 = 'C252'|
DIAG08 = 'C253'|
DIAG08 = 'C254'|
DIAG08 = 'C257'|
DIAG08 = 'C258'|
DIAG08 = 'C259'|
```

```
DIAG08 = 'C787'|
DIAG08 =
'C376')HPBCA8 = 1.
EXECUTE.

COMPUTE HPBCA9 = 0.
EXECUTE.
IF (DIAG09 = 'C220'|
DIAG09 = 'C221'|
DIAG09 = 'C222'|
DIAG09 = 'C223'|
DIAG09 = 'C224'|
DIAG09 = 'C227'|
DIAG09 = 'C229'|
DIAG09 = 'C23X'|
DIAG09 = 'C240'|
DIAG09 = 'C241'|
DIAG09 = 'C248'|
DIAG09 = 'C249'|
DIAG09 = 'C250'|
DIAG09 = 'C251'|
DIAG09 = 'C252'|
DIAG09 = 'C253'|
DIAG09 = 'C254'|
DIAG09 = 'C257'|
DIAG09 = 'C258'|
DIAG09 = 'C259'|
DIAG09 = 'C787'|
DIAG09 =
'C376')HPBCA9 = 1.
EXECUTE.

COMPUTE HPBCA10 =
0.
EXECUTE.
IF (DIAG10 = 'C220'|
DIAG10 = 'C221'|
DIAG10 = 'C222'|
DIAG10 = 'C223'|
DIAG10 = 'C224'|
DIAG10 = 'C227'|
DIAG10 = 'C229'|
DIAG10 = 'C23X'|
DIAG10 = 'C240'|
DIAG10 = 'C241'|
DIAG10 = 'C248'|
DIAG10 = 'C249'|
DIAG10 = 'C250'|
DIAG10 = 'C251'|
DIAG10 = 'C252'|
DIAG10 = 'C253'|
DIAG10 = 'C254'|
DIAG10 = 'C257'|
DIAG10 = 'C258'|
DIAG10 = 'C259'|
DIAG10 = 'C787'|
DIAG10 =
'C376')HPBCA10 = 1.
EXECUTE.

COMPUTE HPBCA11 =
0.
EXECUTE.
IF (DIAG11 = 'C220'|
DIAG11 = 'C221'|
DIAG11 = 'C222'|
DIAG11 = 'C223'|
DIAG11 = 'C224'|
DIAG11 = 'C227'|
DIAG11 = 'C229'|
DIAG11 = 'C23X'|
DIAG11 = 'C240'|
DIAG11 = 'C241'|
DIAG11 = 'C248'|
DIAG11 = 'C249'|
DIAG11 = 'C250'|
DIAG11 = 'C251'|
DIAG11 = 'C252'|
DIAG11 = 'C253'|
DIAG11 = 'C254'|
DIAG11 = 'C257'|
DIAG11 = 'C258'|
DIAG11 = 'C259'|
DIAG11 = 'C787'|
DIAG11 =
'C376')HPBCA11 = 1.
EXECUTE.

COMPUTE HPBCA12 =
0.
EXECUTE.
IF (DIAG12 = 'C220'|
DIAG12 = 'C221'|
DIAG12 = 'C222'|
DIAG12 = 'C223'|
DIAG12 = 'C224'|
DIAG12 = 'C227'|
DIAG12 = 'C229'|
DIAG12 = 'C23X'|
DIAG12 = 'C240'|
DIAG12 = 'C241'|
DIAG12 = 'C248'|
DIAG12 = 'C249'|
DIAG12 = 'C250'|
DIAG12 = 'C251'|
DIAG12 = 'C252'|
DIAG12 = 'C253'|
DIAG12 = 'C254'|
DIAG12 = 'C257'|
DIAG12 = 'C258'|
DIAG12 = 'C259'|
DIAG12 = 'C787'|
DIAG12 =
'C376')HPBCA12 = 1.
EXECUTE.

COMPUTE HPBCA13 =
0.
EXECUTE.
IF (DIAG13 = 'C220'|
DIAG13 = 'C221'|
DIAG13 = 'C222'|
DIAG13 = 'C223'|
DIAG13 = 'C224'|
DIAG13 = 'C227'|
DIAG13 = 'C229'|
DIAG13 = 'C23X'|
DIAG13 = 'C240'|
DIAG13 = 'C241'|
DIAG13 = 'C248'|
DIAG13 = 'C249'|
DIAG13 = 'C250'|
DIAG13 = 'C251'|
DIAG13 = 'C252'|
DIAG13 = 'C253'|
DIAG13 = 'C254'|
DIAG13 = 'C257'|
DIAG13 = 'C258'|
DIAG13 = 'C259'|
DIAG13 = 'C787'|
DIAG13 =
'C376')HPBCA13 = 1.
EXECUTE.

COMPUTE HPBCA14 =
0.
EXECUTE.
IF (DIAG14 = 'C220'|
DIAG14 = 'C221'|
DIAG14 = 'C222'|
DIAG14 = 'C223'|
DIAG14 = 'C224'|
DIAG14 = 'C227'|
DIAG14 = 'C229'|
DIAG14 = 'C23X'|
DIAG14 = 'C240'|
DIAG14 = 'C241'|
DIAG14 = 'C248'|
DIAG14 = 'C249'|
DIAG14 = 'C250'|
DIAG14 = 'C251'|
DIAG14 = 'C252'|
DIAG14 = 'C253'|
DIAG14 = 'C254'|
DIAG14 = 'C257'|
DIAG14 = 'C258'|
DIAG14 = 'C259'|
DIAG14 = 'C787'|
DIAG14 =
'C376')HPBCA14 = 1.
EXECUTE.
```

## ERCP Syntax 21 – Marker to indicate Trust contributed to BSG audit

```
COMPUTE BSGPARTICIPANT
= 0.
EXECUTE.
IF (PROCODE = 'RAL'|
PROCODE = 'RBL'|
PROCODE = 'RBN'|
PROCODE = 'RDD'|
PROCODE = 'RDE'|
PROCODE = 'REM'|
PROCODE = 'RF4'|
PROCODE = 'RFS'|
PROCODE = 'RFW'|
PROCODE = 'RG2'|
PROCODE = 'RG3'|
PROCODE = 'RJ1'|
PROCODE = 'RJ2'|
PROCODE = 'RJ5'|
PROCODE = 'RJC'|
PROCODE = 'RJN'|
PROCODE = 'RKB'|
PROCODE = 'RL4'|
PROCODE = 'RLQ'|
PROCODE = 'RLT'|
PROCODE = 'RM2'|
PROCODE = 'RM3'|
PROCODE = 'RMC'|
PROCODE = 'RMP'|
PROCODE = 'RN7'|
PROCODE = 'RNA'|
PROCODE = 'RNJ'|
PROCODE = 'RP5'|
PROCODE = 'RQ6'|
PROCODE = 'RQ8'|
PROCODE = 'RQM'|
PROCODE = 'RR1'|
PROCODE = 'RRK'|
PROCODE = 'RTG'|
PROCODE = 'RV8'|
PROCODE = 'RVV'|
PROCODE = 'RVY'|
PROCODE = 'RW3'|
PROCODE = 'RW6'|
PROCODE = 'RWE'|
PROCODE = 'RWF'|
PROCODE = 'RWG'|
PROCODE = 'RWH'|
PROCODE = 'RWJ'|
PROCODE = 'RWP'|
PROCODE = 'RX1'|
PROCODE = 'RXC'|
PROCODE = 'RXH'|
PROCODE = 'RXK'|
PROCODE = 'RXN'|
PROCODE = 'RXR'|
PROCODE = 'RXW'|
PROCODE =
'RYJ')BSGPARTICIPANT = 1.
EXECUTE.
```

## ERCP Syntax 22 – Number of cases contributed to the BSG audit

```
COMPUTE BSGTOTAL = 0.
EXECUTE.
IF (PROCODE = 'RAL')BSGTOTAL = 100.
EXECUTE.
IF (PROCODE = 'RBL')BSGTOTAL = 99.
EXECUTE.
IF (PROCODE = 'RBN')BSGTOTAL = 54.
EXECUTE.
IF (PROCODE = 'RDD')BSGTOTAL = 147.
EXECUTE.
IF (PROCODE = 'RDE')BSGTOTAL = 54.
EXECUTE.
IF (PROCODE = 'REM')BSGTOTAL = 12.
EXECUTE.
IF (PROCODE = 'RF4')BSGTOTAL = 83.
EXECUTE.
IF (PROCODE = 'RFS')BSGTOTAL = 74.
EXECUTE.
IF (PROCODE = 'RFW')BSGTOTAL = 39.
EXECUTE.
IF (PROCODE = 'RG2')BSGTOTAL = 82.
EXECUTE.
IF (PROCODE = 'RG3')BSGTOTAL = 97.
EXECUTE.
IF (PROCODE = 'RJ1')BSGTOTAL = 249.
EXECUTE.
IF (PROCODE = 'RJ2')BSGTOTAL = 54.
EXECUTE.
IF (PROCODE = 'RJC')BSGTOTAL = 59.
EXECUTE.
IF (PROCODE = 'RJN')BSGTOTAL = 36.
EXECUTE.
IF (PROCODE = 'RKB')BSGTOTAL = 152.
EXECUTE.
IF (PROCODE = 'RL4')BSGTOTAL = 81.
EXECUTE.
IF (PROCODE = 'RLQ')BSGTOTAL = 30.
EXECUTE.
IF (PROCODE = 'RLT')BSGTOTAL = 31.
EXECUTE.
IF (PROCODE = 'RM2')BSGTOTAL = 186.
EXECUTE.
IF (PROCODE = 'RM3')BSGTOTAL = 57.
EXECUTE.
IF (PROCODE = 'RMC')BSGTOTAL = 37.
EXECUTE.
IF (PROCODE = 'RMP')BSGTOTAL = 55.
EXECUTE.
IF (PROCODE = 'RN7')BSGTOTAL =127.
EXECUTE.
IF (PROCODE = 'RNA')BSGTOTAL = 235.
EXECUTE.
IF (PROCODE = 'RNJ')BSGTOTAL = 79.
EXECUTE.
IF (PROCODE = 'RP5')BSGTOTAL = 93.
EXECUTE.
IF (PROCODE = 'RQ6')BSGTOTAL = 292.
EXECUTE.
IF (PROCODE = 'RQ8')BSGTOTAL = 74.
EXECUTE.
IF (PROCODE = 'RQM')BSGTOTAL = 216.
EXECUTE.
IF (PROCODE = 'RR1')BSGTOTAL = 103.
EXECUTE.
IF (PROCODE = 'RRK')BSGTOTAL = 137.
EXECUTE.
IF (PROCODE = 'RTG')BSGTOTAL = 38.
EXECUTE.
IF (PROCODE = 'RV8')BSGTOTAL = 93.
EXECUTE.
IF (PROCODE = 'RVV')BSGTOTAL = 170.
EXECUTE.
IF (PROCODE = 'RVY')BSGTOTAL = 24.
EXECUTE.
IF (PROCODE = 'RW3')BSGTOTAL = 65.
EXECUTE.
IF (PROCODE = 'RW6')BSGTOTAL = 137.
EXECUTE.
IF (PROCODE = 'RWE')BSGTOTAL = 84.
EXECUTE.
IF (PROCODE = 'RWF')BSGTOTAL = 24.
EXECUTE.
IF (PROCODE = 'RWG')BSGTOTAL = 73.
EXECUTE.
IF (PROCODE = 'RWH')BSGTOTAL = 126.
EXECUTE.
IF (PROCODE = 'RWJ')BSGTOTAL = 145.
EXECUTE.
IF (PROCODE = 'RWP')BSGTOTAL = 49.
EXECUTE.
IF (PROCODE = 'RX1')BSGTOTAL = 242.
EXECUTE.
IF (PROCODE = 'RXC')BSGTOTAL = 77.
EXECUTE.
IF (PROCODE = 'RXH')BSGTOTAL = 77.
EXECUTE.
IF (PROCODE = 'RXK')BSGTOTAL = 52.
EXECUTE.
IF (PROCODE = 'RXN')BSGTOTAL = 44.
EXECUTE.
IF (PROCODE = 'RXR')BSGTOTAL = 98.
EXECUTE.
IF (PROCODE = 'RXW')BSGTOTAL = 105.
EXECUTE.
```

IF (PROCODE = 'RYJ')BSGTOTAL = 115. EXECUTE

## ERCP Syntax 23 – YZ code marker

```
COMPUTE YZCODES = 0.

EXECUTE.
IF (OPERNT7 = 'Y141'|
OPERNT7 = 'Y142'|
OPERNT7 = 'Y143'|
OPERNT7 = 'Y144'|
OPERNT7 = 'Y148'|
OPERNT7 = 'Y149'|
OPERNT7 = 'Y151'|
OPERNT7 = 'Y152'|
OPERNT7 = 'Y153'|
OPERNT7 = 'Y154'|
OPERNT7 = 'Y156'|
OPERNT7 = 'Y157'|
OPERNT7 = 'Y158'|
OPERNT7 = 'Y159'|
OPERNT7 = 'Y203'|
OPERNT7 = 'Y204'|
OPERNT7 = 'Y211'|
OPERNT7 = 'Y511'|
OPERNT7 = 'Y512'|
OPERNT7 = 'Z300'|
OPERNT7 = 'Z301'|
OPERNT7 = 'Z302'|
OPERNT7 = 'Z303'|
OPERNT7 = 'Z304'|
OPERNT7 = 'Z305'|
OPERNT7 = 'Z306'|
OPERNT7 = 'Z307'|
OPERNT7 = 'Z308'|
OPERNT7 = 'Z309'|
OPERNT7 = 'Z311'|
OPERNT7 = 'Z312'|
OPERNT6 = 'Y141'|
OPERNT6 = 'Y142'|
OPERNT6 = 'Y143'|
OPERNT6 = 'Y144'|
OPERNT6 = 'Y148'|
OPERNT6 = 'Y149'|
OPERNT6 = 'Y151'|
OPERNT6 = 'Y152'|
OPERNT6 = 'Y153'|
OPERNT6 = 'Y154'|
OPERNT6 = 'Y156'|
OPERNT6 = 'Y157'|
OPERNT6 = 'Y158'|
OPERNT6 = 'Y159'|
OPERNT6 = 'Y203'|
OPERNT6 = 'Y204'|
OPERNT6 = 'Y211'|
OPERNT6 = 'Y511'|
OPERNT6 = 'Y512'|
OPERNT6 = 'Z300'|
OPERNT6 = 'Z301'|
OPERNT6 = 'Z302'|
OPERNT6 = 'Z303'|
OPERNT6 = 'Z304'|
OPERNT6 = 'Z305'|
OPERNT6 = 'Z306'|
OPERNT6 = 'Z307'|
OPERNT6 = 'Z308'|
OPERNT6 = 'Z309'|
OPERNT6 = 'Z311'|
OPERNT6 = 'Z312'|
OPERNT5 = 'Y141'|
OPERNT5 = 'Y142'|
OPERNT5 = 'Y143'|
OPERNT5 = 'Y144'|
OPERNT5 = 'Y148'|
OPERNT5 = 'Y149'|
OPERNT5 = 'Y151'|
OPERNT5 = 'Y152'|
OPERNT5 = 'Y153'|
OPERNT5 = 'Y154'|
OPERNT5 = 'Y156'|
OPERNT5 = 'Y157'|
OPERNT5 = 'Y158'|
OPERNT5 = 'Y159'|
OPERNT5 = 'Y203'|
OPERNT5 = 'Y204'|
OPERNT5 = 'Y211'|
OPERNT5 = 'Y511'|
OPERNT5 = 'Y512'|
OPERNT5 = 'Z300'|
OPERNT5 = 'Z301'|
OPERNT5 = 'Z302'|
OPERNT5 = 'Z303'|
OPERNT5 = 'Z304'|
OPERNT5 = 'Z305'|
OPERNT5 = 'Z306'|
OPERNT5 = 'Z307'|
OPERNT5 = 'Z308'|
OPERNT5 = 'Z309'|
OPERNT5 = 'Z311'|
OPERNT5 = 'Z312'|
OPERNT4 = 'Y141'|
OPERNT4 = 'Y142'|
OPERNT4 = 'Y143'|
OPERNT4 = 'Y144'|
OPERNT4 = 'Y148'|
OPERNT4 = 'Y149'|
OPERNT4 = 'Y151'|
OPERNT4 = 'Y152'|
OPERNT4 = 'Y153'|
OPERNT4 = 'Y154'|
OPERNT4 = 'Y156'|
OPERNT4 = 'Y157'|
OPERNT4 = 'Y158'|
OPERNT4 = 'Y159'|
OPERNT4 = 'Y203'|
OPERNT4 = 'Y204'|
OPERNT4 = 'Y211'|
OPERNT4 = 'Y511'|
OPERNT4 = 'Y512'|
OPERNT4 = 'Z300'|
OPERNT4 = 'Z301'|
OPERNT4 = 'Z302'|
OPERNT4 = 'Z303'|
OPERNT4 = 'Z304'|
OPERNT4 = 'Z305'|
OPERNT4 = 'Z306'|
OPERNT4 = 'Z307'|
OPERNT4 = 'Z308'|
OPERNT4 = 'Z309'|
OPERNT4 = 'Z311'|
OPERNT4 = 'Z312'|
OPERNT3 = 'Y141'|
OPERNT3 = 'Y142'|
OPERNT3 = 'Y143'|
OPERNT3 = 'Y144'|
OPERNT3 = 'Y148'|
OPERNT3 = 'Y149'|
OPERNT3 = 'Y151'|
OPERNT3 = 'Y152'|
```

```
OPERNT3 = 'Y153'|
OPERNT3 = 'Y154'|
OPERNT3 = 'Y156'|
OPERNT3 = 'Y157'|
OPERNT3 = 'Y158'|
OPERNT3 = 'Y159'|
OPERNT3 = 'Y203'|
OPERNT3 = 'Y204'|
OPERNT3 = 'Y211'|
OPERNT3 = 'Y511'|
OPERNT3 = 'Y512'|
OPERNT3 = 'Z300'|
OPERNT3 = 'Z301'|
OPERNT3 = 'Z302'|
OPERNT3 = 'Z303'|
OPERNT3 = 'Z304'|
OPERNT3 = 'Z305'|
OPERNT3 = 'Z306'|
OPERNT3 = 'Z307'|
OPERNT3 = 'Z308'|
OPERNT3 = 'Z309'|
OPERNT3 = 'Z311'|
OPERNT3 = 'Z312'|
OPERNT2 = 'Y141'|
OPERNT2 = 'Y142'|
OPERNT2 = 'Y143'|
OPERNT2 = 'Y144'|
OPERNT2 = 'Y148'|
OPERNT2 = 'Y149'|
OPERNT2 = 'Y151'|
OPERNT2 = 'Y152'|
OPERNT2 = 'Y153'|
OPERNT2 = 'Y154'|
OPERNT2 = 'Y156'|
OPERNT2 = 'Y157'|
OPERNT2 = 'Y158'|
OPERNT2 = 'Y159'|
OPERNT2 = 'Y203'|
OPERNT2 = 'Y204'|
OPERNT2 = 'Y211'|
OPERNT2 = 'Y511'|
OPERNT2 = 'Y512'|
OPERNT2 = 'Z300'|
OPERNT2 = 'Z301'|
OPERNT2 = 'Z302'|
OPERNT2 = 'Z303'|
OPERNT2 = 'Z304'|
OPERNT2 = 'Z305'|
OPERNT2 = 'Z306'|
OPERNT2 = 'Z307'|
OPERNT2 = 'Z308'|
OPERNT2 = 'Z309'|
OPERNT2 = 'Z311'|
OPERNT2 = 'Z312'|
OPERNT1 = 'Y141'|
OPERNT1 = 'Y142'|
OPERNT1 = 'Y143'|
OPERNT1 = 'Y144'|
OPERNT1 = 'Y148'|
OPERNT1 = 'Y149'|
OPERNT1 = 'Y151'|
OPERNT1 = 'Y152'|
OPERNT1 = 'Y153'|
OPERNT1 = 'Y154'|
OPERNT1 = 'Y156'|
OPERNT1 = 'Y157'|
OPERNT1 = 'Y158'|
OPERNT1 = 'Y159'|
OPERNT1 = 'Y203'|
OPERNT1 = 'Y204'|
OPERNT1 = 'Y211'|
OPERNT1 = 'Y511'|
OPERNT1 = 'Y512'|
OPERNT1 = 'Z300'|
OPERNT1 = 'Z301'|
OPERNT1 = 'Z302'|
OPERNT1 = 'Z303'|
OPERNT1 = 'Z304'|
OPERNT1 = 'Z305'|
OPERNT1 = 'Z306'|
OPERNT1 = 'Z307'|
OPERNT1 = 'Z308'|
OPERNT1 = 'Z309'|
OPERNT1 = 'Z311'|
OPERNT1 = 'Z312')YZCODES
= 1.
EXECUTE
```

**PEG Syntax 1 Extracting PEG episodes**

'Select cases if': OPERTN1 = 'G341' | OPERTN1 = 'G342' | OPERTN1 = 'G343' |

OPERTN1 = 'G344' | OPERTN1 = 'G345' | OPERTN1 = 'G348' | OPERTN1 = 'G349' |

OPERTN1 = 'G361' | OPERTN1 = 'G363' | OPERTN1 = 'G368' | OPERTN1 = 'G369' |

OPERTN1 = 'G445' | OPERTN1 = 'G448'

**PEG Syntax 2 – G445 code present**

```
COMPUTE PEGINSERT1 = 0.
EXECUTE.
IF (OPERTN1 = 'G445')PEGINSERT1 = 1.
EXECUTE.
COMPUTE PEGINSERT2 = 0.
EXECUTE.
IF (OPERTN2 = 'G445')PEGINSERT2 = 1.
EXECUTE.
COMPUTE PEGINSERT3 = 0.
EXECUTE.
IF (OPERTN3 = 'G445')PEGINSERT3 = 1.
EXECUTE.
COMPUTE PEGINSERT4 = 0.
EXECUTE.
IF (OPERTN4 = 'G445')PEGINSERT4 = 1.
EXECUTE.
COMPUTE PEGINSERT5 = 0.
EXECUTE.
IF (OPERTN5 = 'G445')PEGINSERT5 = 1.
EXECUTE.
COMPUTE PEGINSERT6 = 0.
EXECUTE.
IF (OPERTN6 = 'G445')PEGINSERT6 = 1.
EXECUTE.
COMPUTE PEGINSERT7 = 0.
EXECUTE.
IF (OPERTN7 = 'G445')PEGINSERT7 = 1.
EXECUTE.
```

**PEG Syntax 3 – Assign PEG procedure code position**

```
COMPUTE PEG = 0.

EXECUTE.
IF (OPERTN1= 'G341'|
OPERTN1= 'G342'|
OPERTN1= 'G343'|
OPERTN1= 'G344'|
OPERTN1= 'G345'|
OPERTN1= 'G348'|
OPERTN1= 'G349'|
OPERTN1= 'G361'|
OPERTN1= 'G363'|
OPERTN1= 'G368'|
OPERTN1= 'G369'|
OPERTN1= 'G445'|
OPERTN1= 'G448')PEG = 1.
EXECUTE.

COMPUTE PEG = 0.
EXECUTE.
IF (OPERTN2= 'G341'|
OPERTN2= 'G342'|
OPERTN2= 'G343'|
OPERTN2= 'G344'|
OPERTN2= 'G345'|
OPERTN2= 'G348'|
OPERTN2= 'G349'|
OPERTN2= 'G361'|
OPERTN2= 'G363'|
OPERTN2= 'G368'|
OPERTN2= 'G369'|
OPERTN2= 'G445'|
OPERTN2= 'G448')PEG = 2.
EXECUTE.

COMPUTE PEG = 0.
EXECUTE.
IF (OPERTN3= 'G341'|
OPERTN3= 'G342'|
OPERTN3= 'G343'|
OPERTN3= 'G344'|
OPERTN3= 'G345'|
OPERTN3= 'G348'|
OPERTN3= 'G349'|
OPERTN3= 'G361'|
OPERTN3= 'G363'|
OPERTN3= 'G368'|
OPERTN3= 'G369'|
OPERTN3= 'G445'|
OPERTN3= 'G448')PEG = 3.
EXECUTE.

COMPUTE PEG = 0.
EXECUTE.
IF (OPERTN4= 'G341'|
OPERTN4= 'G342'|
OPERTN4= 'G343'|
OPERTN4= 'G344'|
OPERTN4= 'G345'|
OPERTN4= 'G348'|
OPERTN4= 'G349'|
OPERTN4= 'G361'|
OPERTN4= 'G363'|
OPERTN4= 'G368'|
OPERTN4= 'G369'|
OPERTN4= 'G445'|
OPERTN4= 'G448')PEG = 4.
EXECUTE.

COMPUTE PEG = 0.
EXECUTE.
IF (OPERTN5= 'G341'|
OPERTN5= 'G342'|
OPERTN5= 'G343'|
OPERTN5= 'G344'|
OPERTN5= 'G345'|
OPERTN5= 'G348'|
OPERTN5= 'G349'|
OPERTN5= 'G361'|
OPERTN5= 'G363'|
OPERTN5= 'G368'|
OPERTN5= 'G369'|
OPERTN5= 'G445'|
OPERTN5= 'G448')PEG = 5.
EXECUTE.

COMPUTE PEG = 0.
EXECUTE.
IF (OPERTN6= 'G341'|
OPERTN6= 'G342'|
OPERTN6= 'G343'|
OPERTN6= 'G344'|
OPERTN6= 'G345'|
OPERTN6= 'G348'|
OPERTN6= 'G349'|
OPERTN6= 'G361'|
OPERTN6= 'G363'|
OPERTN6= 'G368'|
OPERTN6= 'G369'|
OPERTN6= 'G445'|
OPERTN6= 'G448')PEG = 6.
EXECUTE.

COMPUTE PEG = 0.
EXECUTE.
IF (OPERTN7= 'G341'|
OPERTN7= 'G342'|
OPERTN7= 'G343'|
OPERTN7= 'G344'|
OPERTN7= 'G345'|
OPERTN7= 'G348'|
OPERTN7= 'G349'|
OPERTN7= 'G361'|
OPERTN7= 'G363'|
OPERTN7= 'G368'|
OPERTN7= 'G369'|
OPERTN7= 'G445'|
OPERTN7= 'G448')PEG = 7.
EXECUTE.

COMPUTE PEG = 0.
EXECUTE.
IF (OPERTN8= 'G341'|
OPERTN8= 'G342'|
OPERTN8= 'G343'|
OPERTN8= 'G344'|
OPERTN8= 'G345'|
OPERTN8= 'G348'|
OPERTN8= 'G349'|
OPERTN8= 'G361'|
OPERTN8= 'G363'|
OPERTN8= 'G368'|
```

```
OPERTN8= 'G369'|
OPERTN8= 'G445'|
OPERTN8= 'G448')PEG = 8.
EXECUTE.

COMPUTE PEG = 0.
EXECUTE.
IF (OPERTN9= 'G341'|
OPERTN9= 'G342'|
OPERTN9= 'G343'|
OPERTN9= 'G344'|
OPERTN9= 'G345'|
OPERTN9= 'G348'|
OPERTN9= 'G349'|
OPERTN9= 'G361'|
OPERTN9= 'G363'|
OPERTN9= 'G368'|
OPERTN9= 'G369'|
OPERTN9= 'G445'|
OPERTN9= 'G448')PEG = 9.
EXECUTE.

COMPUTE PEG = 0.
EXECUTE.
IF (OPERTN10= 'G341'|
OPERTN10= 'G342'|
OPERTN10= 'G343'|
OPERTN10= 'G344'|
OPERTN10= 'G345'|
OPERTN10= 'G348'|
OPERTN10= 'G349'|
OPERTN10= 'G361'|
OPERTN10= 'G363'|
OPERTN10= 'G368'|
OPERTN10= 'G369'|
OPERTN10= 'G445'|
OPERTN10= 'G448')PEG =
10.
EXECUTE.

COMPUTE PEG = 0.
EXECUTE.
IF (OPERTN11= 'G341'|
OPERTN11= 'G342'|
OPERTN11= 'G343'|
OPERTN11= 'G344'|
OPERTN11= 'G345'|
OPERTN11= 'G348'|
OPERTN11= 'G349'|
OPERTN11= 'G361'|
OPERTN11= 'G363'|
OPERTN11= 'G368'|
OPERTN11= 'G369'|
OPERTN11= 'G445'|
OPERTN11= 'G448')PEG =
11.
EXECUTE.

COMPUTE PEG = 0.
EXECUTE.
IF (OPERTN12= 'G341'|
OPERTN12= 'G342'|
OPERTN12= 'G343'|
OPERTN12= 'G344'|
OPERTN12= 'G345'|
OPERTN12= 'G348'|
OPERTN12= 'G349'|
OPERTN12= 'G361'|
OPERTN12= 'G363'|
OPERTN12= 'G368'|
OPERTN12= 'G369'|
OPERTN12= 'G445'|
OPERTN12= 'G448')PEG =
12.
EXECUTE.
```

## PEG Syntax 4 – PEG procedure date before admission date

```
COMPUTE PEGDATEB4ADMISSION = 0.

EXECUTE.

IF (PEGDATE1 < ADMIDATE1)PEGDATEB4ADMISSION = 1.
EXECUTE.
```

## PEG Syntax 5 – Date of death before PEG procedure date

```
COMPUTE DEATHDATEB4PEG = 0.
EXECUTE.

IF (DEATHDATE < PEGDATE1)DEATHDATEB4PEG = 1.
EXECUTE.
```

## PEG Syntax 6 – Non-stroke, non-cancer comorbidity code present

```
COMPUTE
NONSTROKENONCANCERCOM
ORB1 = 0.

EXECUTE.
IF (DIAG01 = 'I210'|
DIAG01 = 'I211'|
DIAG01 = 'I212'|
DIAG01 = 'I213'|
DIAG01 = 'I214'|
DIAG01 = 'I219'|
DIAG01 = 'I220'|
DIAG01 = 'I221'|
DIAG01 = 'I228'|
DIAG01 = 'I229'|
DIAG01 = 'I252'|
DIAG01 = 'I500'|
DIAG01 = 'I710'|
DIAG01 = 'I711'|
DIAG01 = 'I712'|
DIAG01 = 'I713'|
DIAG01 = 'I714'|
DIAG01 = 'I715'|
DIAG01 = 'I716'|
DIAG01 = 'I718'|
DIAG01 = 'I719'|
DIAG01 = 'I738'|
DIAG01 = 'I739'|
DIAG01 = 'F000'|
DIAG01 = 'F001'|
DIAG01 = 'F002'|
DIAG01 = 'F009'|
DIAG01 = 'F010'|
DIAG01 = 'F011'|
DIAG01 = 'F012'|
DIAG01 = 'F013'|
DIAG01 = 'F018'|
DIAG01 = 'F019'|
DIAG01 = 'F020'|
DIAG01 = 'F021'|
DIAG01 = 'F022'|
DIAG01 = 'F023'|
DIAG01 = 'F024'|
DIAG01 = 'F028'|
DIAG01 = 'F03X'|
DIAG01 = 'F051'|
DIAG01 = 'J40X'|
DIAG01 = 'J410'|
DIAG01 = 'J411'|
DIAG01 = 'J418'|
DIAG01 = 'J42X'|
DIAG01 = 'J430'|
DIAG01 = 'J431'|
DIAG01 = 'J432'|
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DIAG01 = 'J439'|
DIAG01 = 'J440'|
DIAG01 = 'J441'|
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DIAG01 = 'J450'|
DIAG01 = 'J451'|
DIAG01 = 'J458'|
DIAG01 = 'J459'|
DIAG01 = 'J46X'|
DIAG01 = 'J47X'|
DIAG01 = 'J60X'|
DIAG01 = 'J61X'|
DIAG01 = 'J620'|
DIAG01 = 'J628'|
DIAG01 = 'J630'|
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DIAG01 = 'M303'|
DIAG01 = 'M308'|
DIAG01 = 'M310'|
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DIAG01 = 'M311'|
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DIAG01 = 'M315'|
DIAG01 = 'M316'|
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DIAG01 = 'K265'|
DIAG01 = 'K266'|
DIAG01 = 'K267'|
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DIAG01 = 'K270'|
DIAG01 = 'K271'|
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DIAG01 = 'K275'|
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DIAG01 = 'K704'|
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DIAG01 = 'K715'|
DIAG01 = 'K716'|
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DIAG01 = 'K718'|
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DIAG01 = 'K732'|
DIAG01 = 'K738'|
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DIAG01 = 'K768'|
DIAG01 = 'E102'|
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DIAG01 = 'E136'|
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DIAG01 = 'N005'|
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DIAG01 = 'N012'|
DIAG01 = 'N013'|
DIAG01 = 'N014'|
DIAG01 = 'N015'|
DIAG01 = 'N016'|
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DIAG01 = 'N019'|
DIAG01 = 'N020'|
DIAG01 = 'N021'|
DIAG01 = 'N022'|
DIAG01 = 'N023'|
DIAG01 = 'N024'|
DIAG01 = 'N025'|
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DIAG01 = 'N043'|
DIAG01 = 'N044'|
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DIAG01 = 'N047'|
DIAG01 = 'N048'|
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DIAG01 = 'N074'|
DIAG01 = 'N075'|
DIAG01 = 'N180'|
DIAG01 = 'N188'|
DIAG01 = 'N189'|
DIAG01 = 'N19X'|
DIAG01 = 'N250'|
DIAG01 = 'Z992'|
DIAG01 = 'B200'|
DIAG01 = 'B201'|
DIAG01 = 'B202'|
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DIAG01 = 'B213'|
DIAG01 = 'B217'|
DIAG01 = 'B218'|
DIAG01 = 'B219'|
DIAG01 = 'B220'|
DIAG01 = 'B221'|
DIAG01 = 'B222'|
DIAG01 = 'B227'|
DIAG01 = 'B230'|
DIAG01 = 'B231'|
DIAG01 = 'B232'|
DIAG01 = 'B238'|
DIAG01 = 'B24X')NONSTROKENONCANCERCOMORB1 = 1.
EXECUTE.

COMPUTE NONSTROKENONCANCERCOMORB2 = 0.
EXECUTE.
IF (DIAG02 = 'I210'|
DIAG02 = 'I211'|
DIAG02 = 'I212'|
DIAG02 = 'I213'|
DIAG02 = 'I214'|
DIAG02 = 'I219'|
DIAG02 = 'I220'|
DIAG02 = 'I221'|
DIAG02 = 'I228'|
DIAG02 = 'I229'|
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DIAG02 = 'I500'|
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DIAG02 = 'J634'|
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DIAG02 = 'M301'|
DIAG02 = 'M302'|
DIAG02 = 'M303'|
DIAG02 = 'M308'|
DIAG02 = 'M310'|
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DIAG02 = 'M311'|
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DIAG02 = 'M315'|
DIAG02 = 'M316'|
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DIAG02 = 'K264'|
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DIAG02 = 'K275'|
DIAG02 = 'K276'|
DIAG02 = 'K277'|
DIAG02 = 'K279'|
DIAG02 = 'K280'|
DIAG02 = 'K281'|
DIAG02 = 'K282'|
DIAG02 = 'K283'|
DIAG02 = 'K284'|
DIAG02 = 'K285'|
DIAG02 = 'K286'|
DIAG02 = 'K287'|
DIAG02 = 'K289'|
DIAG02 = 'K701'|
DIAG02 = 'K702'|
DIAG02 = 'K703'|
DIAG02 = 'K704'|
DIAG02 = 'K709'|
DIAG02 = 'K710'|
DIAG02 = 'K711'|
DIAG02 = 'K712'|
DIAG02 = 'K713'|
DIAG02 = 'K714'|
DIAG02 = 'K715'|
DIAG02 = 'K716'|
DIAG02 = 'K717'|
DIAG02 = 'K718'|
DIAG02 = 'K719'|
DIAG02 = 'K721'|
DIAG02 = 'K729'|
DIAG02 = 'K730'|
DIAG02 = 'K731'|
DIAG02 = 'K732'|
DIAG02 = 'K738'|
DIAG02 = 'K739'|
DIAG02 = 'K740'|
DIAG02 = 'K741'|
DIAG02 = 'K742'|
DIAG02 = 'K743'|
DIAG02 = 'K744'|
DIAG02 = 'K745'|
DIAG02 = 'K746'|
DIAG02 = 'K753'|
DIAG02 = 'K754'|
DIAG02 = 'K758'|
DIAG02 = 'K764'|
DIAG02 = 'K765'|
DIAG02 = 'K766'|
DIAG02 = 'K767'|
DIAG02 = 'K768'|
DIAG02 = 'E102'|
DIAG02 = 'E103'|
DIAG02 = 'E104'|
DIAG02 = 'E105'|
DIAG02 = 'E106'|
DIAG02 = 'E107'|
DIAG02 = 'E108'|
DIAG02 = 'E109'|
DIAG02 = 'E112'|
DIAG02 = 'E113'|
DIAG02 = 'E114'|
DIAG02 = 'E115'|
DIAG02 = 'E116'|
DIAG02 = 'E117'|
DIAG02 = 'E118'|
DIAG02 = 'E119'|
DIAG02 = 'E132'|
DIAG02 = 'E133'|
DIAG02 = 'E134'|
DIAG02 = 'E135'|
DIAG02 = 'E136'|
DIAG02 = 'E137'|
DIAG02 = 'E138'|
DIAG02 = 'E139'|
DIAG02 = 'E142'|
DIAG02 = 'E143'|
DIAG02 = 'E144'|
DIAG02 = 'E145'|
DIAG02 = 'E146'|
DIAG02 = 'E147'|
DIAG02 = 'E148'|
DIAG02 = 'E149'|
DIAG02 = 'N001'|
DIAG02 = 'N002'|
DIAG02 = 'N003'|
DIAG02 = 'N004'|
DIAG02 = 'N005'|
DIAG02 = 'N007'|
DIAG02 = 'N010'|
DIAG02 = 'N011'|
DIAG02 = 'N012'|
DIAG02 = 'N013'|
DIAG02 = 'N014'|
DIAG02 = 'N015'|
DIAG02 = 'N016'|
DIAG02 = 'N017'|
DIAG02 = 'N018'|
DIAG02 = 'N019'|
DIAG02 = 'N020'|
DIAG02 = 'N021'|
DIAG02 = 'N022'|
DIAG02 = 'N023'|
DIAG02 = 'N024'|
DIAG02 = 'N025'|
DIAG02 = 'N026'|
DIAG02 = 'N027'|
DIAG02 = 'N030'|
DIAG02 = 'N031'|
DIAG02 = 'N032'|
DIAG02 = 'N033'|
DIAG02 = 'N034'|
DIAG02 = 'N035'|
DIAG02 = 'N036'|
DIAG02 = 'N037'|
DIAG02 = 'N038'|

DIAG02 = 'N039'|
DIAG02 = 'N040'|
DIAG02 = 'N041'|
DIAG02 = 'N042'|
DIAG02 = 'N043'|
DIAG02 = 'N044'|
DIAG02 = 'N045'|
DIAG02 = 'N046'|
DIAG02 = 'N047'|
DIAG02 = 'N048'|
DIAG02 = 'N049'|
DIAG02 = 'N050'|
DIAG02 = 'N051'|
DIAG02 = 'N052'|
DIAG02 = 'N053'|
DIAG02 = 'N054'|
DIAG02 = 'N055'|
DIAG02 = 'N056'|
DIAG02 = 'N057'|
DIAG02 = 'N071'|
DIAG02 = 'N072'|
DIAG02 = 'N073'|
DIAG02 = 'N074'|
DIAG02 = 'N075'|
DIAG02 = 'N180'|
DIAG02 = 'N188'|
DIAG02 = 'N189'|
DIAG02 = 'N19X'|
DIAG02 = 'N250'|
DIAG02 = 'Z992'|
DIAG02 = 'B200'|
DIAG02 = 'B201'|
DIAG02 = 'B202'|
DIAG02 = 'B203'|
DIAG02 = 'B204'|
DIAG02 = 'B205'|
DIAG02 = 'B206'|
DIAG02 = 'B207'|
DIAG02 = 'B208'|
DIAG02 = 'B209'|
DIAG02 = 'B210'|
DIAG02 = 'B211'|
DIAG02 = 'B212'|
DIAG02 = 'B213'|
DIAG02 = 'B217'|
DIAG02 = 'B218'|
DIAG02 = 'B219'|
DIAG02 = 'B220'|
DIAG02 = 'B221'|
DIAG02 = 'B222'|
DIAG02 = 'B227'|
DIAG02 = 'B230'|
DIAG02 = 'B231'|
DIAG02 = 'B232'|
DIAG02 = 'B238'|
DIAG02 = 'B24X')NONSTROKENONCANCERCOMORB2 = 1.
EXECUTE

Then repeat as above for ICD-10 code positions 3 through 20

## PEG Syntax 7 – Stroke code present

```
COMPUTE STROKE1 = 0.

EXECUTE.
IF(DIAG01 = 'G450'|
DIAG01 = 'G451'|
DIAG01 = 'G452'|
DIAG01 = 'G454'|
DIAG01 = 'G458'|
DIAG01 = 'G459'|
DIAG01 = 'G460'|
DIAG01 = 'G461'|
DIAG01 = 'G462'|
DIAG01 = 'G463'|
DIAG01 = 'G464'|
DIAG01 = 'G465'|
DIAG01 = 'G466'|
DIAG01 = 'G467'|
DIAG01 = 'G468'|
DIAG01 = 'I600'|
DIAG01 = 'I601'|
DIAG01 = 'I602'|
DIAG01 = 'I603'|
DIAG01 = 'I604'|
DIAG01 = 'I605'|
DIAG01 = 'I606'|
DIAG01 = 'I607'|
DIAG01 = 'I608'|
DIAG01 = 'I609'|
DIAG01 = 'I610'|
DIAG01 = 'I611'|
DIAG01 = 'I612'|
DIAG01 = 'I613'|
DIAG01 = 'I614'|
DIAG01 = 'I615'|
DIAG01 = 'I616'|
DIAG01 = 'I618'|
DIAG01 = 'I619'|
DIAG01 = 'I620'|
DIAG01 = 'I621'|
DIAG01 = 'I629'|
DIAG01 = 'I630'|
DIAG01 = 'I631'|
DIAG01 = 'I632'|
DIAG01 = 'I633'|
DIAG01 = 'I634'|
DIAG01 = 'I635'|
DIAG01 = 'I636'|
DIAG01 = 'I638'|
DIAG01 = 'I639'|
DIAG01 = 'I64X'|
DIAG01 = 'I650'|
DIAG01 = 'I651'|
DIAG01 = 'I652'|
DIAG01 = 'I653'|
DIAG01 = 'I658'|
DIAG01 = 'I659'|
DIAG01 = 'I660'|
DIAG01 = 'I661'|
DIAG01 = 'I662'|
DIAG01 = 'I663'|
DIAG01 = 'I664'|
DIAG01 = 'I668'|
DIAG01 = 'I669'|
DIAG01 = 'I670'|
DIAG01 = 'I671'|
DIAG01 = 'I672'|
DIAG01 = 'I673'|
DIAG01 = 'I674'|
DIAG01 = 'I675'|
DIAG01 = 'I676'|
DIAG01 = 'I677'|
DIAG01 = 'I678'|
DIAG01 = 'I679'|
DIAG01 = 'I681'|
DIAG01 = 'I682'|
DIAG01 = 'I688'|
DIAG01 = 'I690'|
DIAG01 = 'I691'|
DIAG01 = 'I692'|
DIAG01 = 'I693'|
DIAG01 = 'I694'|
DIAG01 = 'I698'|
DIAG01 = 'G820'|
DIAG01 = 'G821'|
DIAG01 = 'G822'|
DIAG01 = 'G810'|
DIAG01 = 'G811'|
DIAG01 = 'G819'|
DIAG01 = 'G041')STROKE1 =
1.
EXECUTE.

COMPUTE STROKE2 = 0.
EXECUTE.
IF(DIAG02 = 'G450'|
DIAG02 = 'G451'|
DIAG02 = 'G452'|
DIAG02 = 'G454'|
DIAG02 = 'G458'|
DIAG02 = 'G459'|
DIAG02 = 'G460'|
DIAG02 = 'G461'|
DIAG02 = 'G462'|
DIAG02 = 'G463'|
DIAG02 = 'G464'|
DIAG02 = 'G465'|
DIAG02 = 'G466'|
DIAG02 = 'G467'|
DIAG02 = 'G468'|
DIAG02 = 'I600'|
DIAG02 = 'I601'|
DIAG02 = 'I602'|
DIAG02 = 'I603'|
DIAG02 = 'I604'|
DIAG02 = 'I605'|
DIAG02 = 'I606'|
DIAG02 = 'I607'|
DIAG02 = 'I608'|
DIAG02 = 'I609'|
DIAG02 = 'I610'|
DIAG02 = 'I611'|
DIAG02 = 'I612'|
DIAG02 = 'I613'|
DIAG02 = 'I614'|
DIAG02 = 'I615'|
DIAG02 = 'I616'|
DIAG02 = 'I618'|
DIAG02 = 'I619'|
DIAG02 = 'I620'|
DIAG02 = 'I621'|
DIAG02 = 'I629'|
DIAG02 = 'I630'|
DIAG02 = 'I631'|
DIAG02 = 'I632'|
DIAG02 = 'I633'|
DIAG02 = 'I634'|
DIAG02 = 'I635'|
DIAG02 = 'I636'|
DIAG02 = 'I638'|
DIAG02 = 'I639'|
DIAG02 = 'I64X'|
DIAG02 = 'I650'|
```

```
DIAG02 = 'I651'|
DIAG02 = 'I652'|
DIAG02 = 'I653'|
DIAG02 = 'I658'|
DIAG02 = 'I659'|
DIAG02 = 'I660'|
DIAG02 = 'I661'|
DIAG02 = 'I662'|
DIAG02 = 'I663'|
DIAG02 = 'I664'|
DIAG02 = 'I668'|
DIAG02 = 'I669'|
DIAG02 = 'I670'|
DIAG02 = 'I671'|
DIAG02 = 'I672'|
DIAG02 = 'I673'|
DIAG02 = 'I674'|
DIAG02 = 'I675'|
DIAG02 = 'I676'|
DIAG02 = 'I677'|
DIAG02 = 'I678'|
DIAG02 = 'I679'|
DIAG02 = 'I681'|
DIAG02 = 'I682'|
DIAG02 = 'I688'|
DIAG02 = 'I690'|
DIAG02 = 'I691'|
DIAG02 = 'I692'|
DIAG02 = 'I693'|
DIAG02 = 'I694'|
DIAG02 = 'I698'|
DIAG02 = 'G820'|
DIAG02 = 'G821'|
DIAG02 = 'G822'|
DIAG02 = 'G810'|
DIAG02 = 'G811'|
DIAG02 = 'G819'|
DIAG02 = 'G041')STROKE2 =
1.
EXECUTE
.
```

Then repeat as above for ICD-10 code positions 3 through 20

## PEG Syntax 8 – Dementia code present

```
COMPUTE DEMENTIA1 = 0.

EXECUTE.
IF(DIAG01 = 'F000'|
DIAG01 = 'F001'|
DIAG01 = 'F009'|
DIAG01 = 'F011'|
DIAG01 = 'F019'|
DIAG01 = 'F020'|
DIAG01 = 'F022'|
DIAG01 = 'F023'|
DIAG01 = 'F024'|
DIAG01 = 'F028'|
DIAG01 = 'F03X'|
DIAG01 = 'F051'|
DIAG01 = 'G300'|
DIAG01 = 'G301'|
DIAG01 = 'G309')DEMENTIA1 =
1.
EXECUTE.
COMPUTE DEMENTIA2 = 0.
EXECUTE.
IF(DIAG02 = 'F000'|
DIAG02 = 'F001'|
DIAG02 = 'F009'|
DIAG02 = 'F011'|
DIAG02 = 'F019'|
DIAG02 = 'F020'|
DIAG02 = 'F022'|
DIAG02 = 'F023'|
DIAG02 = 'F024'|
DIAG02 = 'F028'|
DIAG02 = 'F03X'|
DIAG02 = 'F051'|
DIAG02 = 'G300'|
DIAG02 = 'G301'|
DIAG02 = 'G309')DEMENTIA2 =
1.
EXECUTE.
COMPUTE DEMENTIA3 = 0.
EXECUTE.
IF(DIAG03 = 'F000'|
DIAG03 = 'F001'|
DIAG03 = 'F009'|
DIAG03 = 'F011'|
DIAG03 = 'F019'|
DIAG03 = 'F020'|
DIAG03 = 'F022'|
DIAG03 = 'F023'|
DIAG03 = 'F024'|
DIAG03 = 'F028'|
DIAG03 = 'F03X'|
DIAG03 = 'F051'|
DIAG03 = 'G300'|
DIAG03 = 'G301'|
DIAG03 = 'G309')DEMENTIA3 =
1.
EXECUTE.
COMPUTE DEMENTIA4 = 0.
EXECUTE.
IF(DIAG04 = 'F000'|
DIAG04 = 'F001'|
DIAG04 = 'F009'|
DIAG04 = 'F011'|
DIAG04 = 'F019'|
DIAG04 = 'F020'|
DIAG04 = 'F022'|
DIAG04 = 'F023'|
DIAG04 = 'F024'|
DIAG04 = 'F028'|
DIAG04 = 'F03X'|
DIAG04 = 'F051'|
DIAG04 = 'G300'|
DIAG04 = 'G301'|
DIAG04 = 'G309')DEMENTIA4 =
1.
EXECUTE.

COMPUTE DEMENTIA5 = 0.
EXECUTE.
IF(DIAG05 = 'F000'|
DIAG05 = 'F001'|
DIAG05 = 'F009'|
DIAG05 = 'F011'|
DIAG05 = 'F019'|
DIAG05 = 'F020'|
DIAG05 = 'F022'|
DIAG05 = 'F023'|
DIAG05 = 'F024'|
DIAG05 = 'F028'|
DIAG05 = 'F03X'|
DIAG05 = 'F051'|
DIAG05 = 'G300'|
DIAG05 = 'G301'|
DIAG05 = 'G309')DEMENTIA5 =
1.
EXECUTE.

COMPUTE DEMENTIA6 = 0.
EXECUTE.
IF(DIAG06 = 'F000'|
DIAG06 = 'F001'|
DIAG06 = 'F009'|
DIAG06 = 'F011'|
DIAG06 = 'F019'|
DIAG06 = 'F020'|
DIAG06 = 'F022'|
DIAG06 = 'F023'|
DIAG06 = 'F024'|
DIAG06 = 'F028'|
DIAG06 = 'F03X'|
DIAG06 = 'F051'|
DIAG06 = 'G300'|
DIAG06 = 'G301'|
DIAG06 = 'G309')DEMENTIA6 =
1.
EXECUTE.

COMPUTE DEMENTIA7 = 0.
EXECUTE.
IF(DIAG07 = 'F000'|
DIAG07 = 'F001'|
DIAG07 = 'F009'|
DIAG07 = 'F011'|
DIAG07 = 'F019'|
DIAG07 = 'F020'|
DIAG07 = 'F022'|
DIAG07 = 'F023'|
DIAG07 = 'F024'|
DIAG07 = 'F028'|
DIAG07 = 'F03X'|
DIAG07 = 'F051'|
DIAG07 = 'G300'|
DIAG07 = 'G301'|
DIAG07 = 'G309')DEMENTIA7 =
1.
EXECUTE.

COMPUTE DEMENTIA8 = 0.
EXECUTE.
IF(DIAG08 = 'F000'|
```

```
DIAG08 = 'F001'|
DIAG08 = 'F009'|
DIAG08 = 'F011'|
DIAG08 = 'F019'|
DIAG08 = 'F020'|
DIAG08 = 'F022'|
DIAG08 = 'F023'|
DIAG08 = 'F024'|
DIAG08 = 'F028'|
DIAG08 = 'F03X'|
DIAG08 = 'F051'|
DIAG08 = 'G300'|
DIAG08 = 'G301'|
DIAG08 = 'G309')DEMENTIA8 =
1.
EXECUTE.

COMPUTE DEMENTIA9 = 0.
EXECUTE.
IF(DIAG09 = 'F000'|
DIAG09 = 'F001'|
DIAG09 = 'F009'|
DIAG09 = 'F011'|
DIAG09 = 'F019'|
DIAG09 = 'F020'|
DIAG09 = 'F022'|
DIAG09 = 'F023'|
DIAG09 = 'F024'|
DIAG09 = 'F028'|
DIAG09 = 'F03X'|
DIAG09 = 'F051'|
DIAG09 = 'G300'|
DIAG09 = 'G301'|
DIAG09 = 'G309')DEMENTIA9 =
1.
EXECUTE.

COMPUTE DEMENTIA10 = 0.
EXECUTE.
IF(DIAG10 = 'F000'|
DIAG10 = 'F001'|
DIAG10 = 'F009'|
DIAG10 = 'F011'|
DIAG10 = 'F019'|
DIAG10 = 'F020'|
DIAG10 = 'F022'|
DIAG10 = 'F023'|
DIAG10 = 'F024'|
DIAG10 = 'F028'|
DIAG10 = 'F03X'|
DIAG10 = 'F051'|
DIAG10 = 'G300'|
DIAG10 = 'G301'|
DIAG10 = 'G309')DEMENTIA10
= 1.
EXECUTE.

COMPUTE DEMENTIA11 = 0.
EXECUTE.
IF(DIAG11 = 'F000'|
DIAG11 = 'F001'|
DIAG11 = 'F009'|
DIAG11 = 'F011'|
DIAG11 = 'F019'|
DIAG11 = 'F020'|
DIAG11 = 'F022'|
DIAG11 = 'F023'|
DIAG11 = 'F024'|
DIAG11 = 'F028'|
DIAG11 = 'F03X'|
DIAG11 = 'F051'|
DIAG11 = 'G300'|
DIAG11 = 'G301'|
DIAG11 = 'G309')DEMENTIA11
= 1.
EXECUTE.


COMPUTE DEMENTIA12 = 0.
EXECUTE.
IF(DIAG12 = 'F000'|
DIAG12 = 'F001'|
DIAG12 = 'F009'|
DIAG12 = 'F011'|
DIAG12 = 'F019'|
DIAG12 = 'F020'|
DIAG12 = 'F022'|
DIAG12 = 'F023'|
DIAG12 = 'F024'|
DIAG12 = 'F028'|
DIAG12 = 'F03X'|
DIAG12 = 'F051'|
DIAG12 = 'G300'|
DIAG12 = 'G301'|
DIAG12 = 'G309')DEMENTIA12
= 1.
EXECUTE.

COMPUTE DEMENTIA13 = 0.
EXECUTE.
IF(DIAG13 = 'F000'|
DIAG13 = 'F001'|
DIAG13 = 'F009'|
DIAG13 = 'F011'|
DIAG13 = 'F019'|
DIAG13 = 'F020'|
DIAG13 = 'F022'|
DIAG13 = 'F023'|
DIAG13 = 'F024'|
DIAG13 = 'F028'|
DIAG13 = 'F03X'|
DIAG13 = 'F051'|
DIAG13 = 'G300'|
DIAG13 = 'G301'|
DIAG13 = 'G309')DEMENTIA13
= 1.
EXECUTE.

COMPUTE DEMENTIA14 = 0.
EXECUTE.
IF(DIAG14 = 'F000'|
DIAG14 = 'F001'|
DIAG14 = 'F009'|
DIAG14 = 'F011'|
DIAG14 = 'F019'|
DIAG14 = 'F020'|
DIAG14 = 'F022'|
DIAG14 = 'F023'|
DIAG14 = 'F024'|
DIAG14 = 'F028'|
DIAG14 = 'F03X'|
DIAG14 = 'F051'|
DIAG14 = 'G300'|
DIAG14 = 'G301'|
DIAG14 = 'G309')DEMENTIA14
= 1.
EXECUTE.
```

## PEG Syntax 9 – Motor Neurone disease marker

```
COMPUTE MND1 = 0.
EXECUTE.
IF(DIAG01 = 'G122')MND1 =
1.
EXECUTE.

COMPUTE MND2 = 0.
EXECUTE.
IF(DIAG02 = 'G122')MND2 =
1.
EXECUTE.

COMPUTE MND3 = 0.
EXECUTE.
IF(DIAG03 = 'G122')MND3 =
1.
EXECUTE.

COMPUTE MND4 = 0.
EXECUTE.
IF(DIAG04 = 'G122')MND4 =
1.
EXECUTE.

COMPUTE MND5 = 0.
EXECUTE.
IF(DIAG05 = 'G122')MND5 =
1.
EXECUTE.

COMPUTE MND6 = 0.
EXECUTE.
IF(DIAG06 = 'G122')MND6 =
1.
EXECUTE.

COMPUTE MND7 = 0.
EXECUTE.
IF(DIAG07 = 'G122')MND7 =
1.
EXECUTE.

COMPUTE MND8 = 0.
EXECUTE.
IF(DIAG08 = 'G122')MND8 =
1.
EXECUTE.

COMPUTE MND9 = 0.
EXECUTE.
IF(DIAG09 = 'G122')MND9 =
1.
EXECUTE.

COMPUTE MND10 = 0.
EXECUTE.
IF(DIAG10 = 'G122')MND10
= 1.
EXECUTE.
COMPUTE MND11 = 0.
EXECUTE.
IF(DIAG11 = 'G122')MND11
= 1.
EXECUTE.

COMPUTE MND12 = 0.
EXECUTE.
IF(DIAG12 = 'G122')MND12
= 1.
EXECUTE.

COMPUTE MND13 = 0.
EXECUTE.
IF(DIAG13 = 'G122')MND13
= 1.
EXECUTE.

COMPUTE MND14 = 0.
EXECUTE.
IF(DIAG14 = 'G122')MND14
= 1.
EXECUTE.
```

**PEG Syntax 10– Multiple sclerosis code present**

```
COMPUTE MS1 = 0.
EXECUTE.
IF(DIAG01 = 'G35X')MS1 =
1.
EXECUTE.

COMPUTE MS2 = 0.
EXECUTE.
IF(DIAG02 = 'G35X')MS2 =
1.
EXECUTE.

COMPUTE MS3 = 0.
EXECUTE.
IF(DIAG03 = 'G35X')MS3 =
1.
EXECUTE.

COMPUTE MS4 = 0.
EXECUTE.
IF(DIAG04 = 'G35X')MS4 =
1.
EXECUTE.

COMPUTE MS5 = 0.
EXECUTE.
IF(DIAG05 = 'G35X')MS5 =
1.
EXECUTE.

COMPUTE MS6 = 0.
EXECUTE.
IF(DIAG06 = 'G35X')MS6 =
1.
EXECUTE.

COMPUTE MS7 = 0.
EXECUTE.
IF(DIAG07 = 'G35X')MS7 =
1.
EXECUTE.

COMPUTE MS8 = 0.
EXECUTE.
IF(DIAG08 = 'G35X')MS8 =
1.
EXECUTE.

COMPUTE MS9 = 0.
EXECUTE.
IF(DIAG09 = 'G35X')MS9 =
1.
EXECUTE.

COMPUTE MS10 = 0.
EXECUTE.
IF(DIAG10 = 'G35X')MS10 =
1.
EXECUTE.

COMPUTE MS11 = 0.
EXECUTE.
IF(DIAG11 = 'G35X')MS11 =
1.
EXECUTE.

COMPUTE MS12 = 0.
EXECUTE.
IF(DIAG12 = 'G35X')MS12 =
1.
EXECUTE.

COMPUTE MS13 = 0.
EXECUTE.
IF(DIAG13 = 'G35X')MS13 =
1.
EXECUTE.

COMPUTE MS14 = 0.
EXECUTE.
IF(DIAG14 = 'G35X')MS14 =
1.
EXECUTE.
```

## PEG Syntax 11 –Parkinson's disease

```
COMPUTE PARKINSONS1 =
0.

EXECUTE.
IF(DIAG01 =
'G20X')PARKINSONS1 = 1.
EXECUTE.

COMPUTE PARKINSONS2 =
0.
EXECUTE.
IF(DIAG02 =
'G20X')PARKINSONS2 = 1.
EXECUTE.

COMPUTE PARKINSONS3 =
0.
EXECUTE.
IF(DIAG03 =
'G20X')PARKINSONS3 = 1.
EXECUTE.

COMPUTE PARKINSONS4 =
0.
EXECUTE.
IF(DIAG04 =
'G20X')PARKINSONS4 = 1.
EXECUTE.

COMPUTE PARKINSONS5 =
0.
EXECUTE.
IF(DIAG05 =
'G20X')PARKINSONS5 = 1.
EXECUTE.

COMPUTE PARKINSONS6 =
0.
EXECUTE.
IF(DIAG06 =
'G20X')PARKINSONS6 = 1.
EXECUTE.

COMPUTE PARKINSONS7 =
0.
EXECUTE.
IF(DIAG07 =
'G20X')PARKINSONS7 = 1.
EXECUTE.

COMPUTE PARKINSONS8 =
0.
EXECUTE.
IF(DIAG08 =
'G20X')PARKINSONS8 = 1.
EXECUTE.

COMPUTE PARKINSONS9 =
0.
EXECUTE.
IF(DIAG09 =
'G20X')PARKINSONS9 = 1.
EXECUTE.
COMPUTE PARKINSONS10 =
0.
EXECUTE.
IF(DIAG10 =
'G20X')PARKINSONS10 = 1.
EXECUTE.

COMPUTE PARKINSONS11 =
0.
EXECUTE.
IF(DIAG11 =
'G20X')PARKINSONS11 = 1.
EXECUTE.

COMPUTE PARKINSONS12 =
0.
EXECUTE.
IF(DIAG12 =
'G20X')PARKINSONS12 = 1.
EXECUTE.

COMPUTE PARKINSONS13 =
0.
EXECUTE.
IF(DIAG13 =
'G20X')PARKINSONS13 = 1.
EXECUTE.

COMPUTE PARKINSONS14 =
0.
EXECUTE.
IF(DIAG14 =
'G20X')PARKINSONS14 = 1.
EXECUTE.
```

## Stroke Syntax 1 – Stroke code

```
COMPUTE STROKE1 = 0.

EXECUTE.

IF(DIAG01 = 'G450'|
DIAG01 = 'G451'|
DIAG01 = 'G460'|
DIAG01 = 'G461'|
DIAG01 = 'G462'|
DIAG01 = 'G463'|
DIAG01 = 'G464'|
DIAG01 = 'G465'|
DIAG01 = 'G467'|
DIAG01 = 'G468'|
DIAG01 = 'G810'|
DIAG01 = 'G811'|
DIAG01 = 'G819'|
DIAG01 = 'I610'|
DIAG01 = 'I611'|
DIAG01 = 'I612'|
DIAG01 = 'I613'|
DIAG01 = 'I614'|
DIAG01 = 'I615'|
DIAG01 = 'I616'|
DIAG01 = 'I618'|
DIAG01 = 'I619'|
DIAG01 = 'I629'|
DIAG01 = 'I630'|
DIAG01 = 'I631'|
DIAG01 = 'I632'|
DIAG01 = 'I633'|
DIAG01 = 'I634'|
DIAG01 = 'I635'|
DIAG01 = 'I636'|
DIAG01 = 'I638'|
DIAG01 = 'I639'|
DIAG01 = 'I64X'|
DIAG01 = 'I650'|
DIAG01 = 'I651'|
DIAG01 = 'I652'|
DIAG01 = 'I653'|
DIAG01 = 'I658'|
DIAG01 = 'I659'|
DIAG01 = 'I660'|
DIAG01 = 'I661'|
DIAG01 = 'I662'|
DIAG01 = 'I663'|
DIAG01 = 'I664'|
DIAG01 = 'I668'|
DIAG01 = 'I669'|
DIAG01 = 'I670'|
DIAG01 = 'I672'|
DIAG01 = 'I678'|
DIAG01 = 'I679'|
DIAG01 = 'I688'|
DIAG01 = 'I691'|
DIAG01 = 'I692'|
DIAG01 = 'I693'|
DIAG01 = 'I694')STROKE1 =
1.
EXECUTE.

COMPUTE STROKE2 = 0.
EXECUTE.

IF(DIAG02 = 'G450'|
DIAG02 = 'G451'|
DIAG02 = 'G460'|
DIAG02 = 'G461'|
DIAG02 = 'G462'|
DIAG02 = 'G463'|
DIAG02 = 'G464'|
DIAG02 = 'G465'|
DIAG02 = 'G467'|
DIAG02 = 'G468'|
DIAG02 = 'G810'|
DIAG02 = 'G811'|
DIAG02 = 'G819'|
DIAG02 = 'I610'|
DIAG02 = 'I611'|
DIAG02 = 'I612'|
DIAG02 = 'I613'|
DIAG02 = 'I614'|
DIAG02 = 'I615'|
DIAG02 = 'I616'|
DIAG02 = 'I618'|
DIAG02 = 'I619'|
DIAG02 = 'I629'|
DIAG02 = 'I630'|
DIAG02 = 'I631'|
DIAG02 = 'I632'|
DIAG02 = 'I633'|
DIAG02 = 'I634'|
DIAG02 = 'I635'|
DIAG02 = 'I636'|
DIAG02 = 'I638'|
DIAG02 = 'I639'|
DIAG02 = 'I64X'|
DIAG02 = 'I650'|
DIAG02 = 'I651'|
DIAG02 = 'I652'|
DIAG02 = 'I653'|
DIAG02 = 'I658'|
DIAG02 = 'I659'|
DIAG02 = 'I660'|
DIAG02 = 'I661'|
DIAG02 = 'I662'|
DIAG02 = 'I663'|
DIAG02 = 'I664'|
DIAG02 = 'I668'|
DIAG02 = 'I669'|
DIAG02 = 'I670'|
DIAG02 = 'I672'|
DIAG02 = 'I678'|
DIAG02 = 'I679'|
DIAG02 = 'I688'|
DIAG02 = 'I691'|
DIAG02 = 'I692'|
DIAG02 = 'I693'|
DIAG02 = 'I694')STROKE2 =
1.
EXECUTE.
```

## Stroke Syntax 2 – Admission method type

This syntax was used to update a new variable called ADMISSMETHTYPE that defines how the patient was admitted to hospital for the spell. First of all, the syntax creates a variable called ADMISSMETHTYPE and sets to 0; it then updates this variable dependant on what code is present in ADMIMETH. If ADMIMETH is equal to 11, 12, 13 then it is an ELECTIVE spell and ADMISSMETHTYPE is then updated to code 1. If ADMIMETH is equal to 21, 22, 23, 24, 28 then it is an EMERGENCY spell and ADMISSMETHTYPE is then updated to code 4. A new variable is now created called ADMMETHTYPE which will take the Admission type and the Patient Classification field which looks how the patient was managed into account. The syntax commands if ADMIMETHTYPE is equal to 1 and CLASS PAT is equal to 1 then update ADMMETHTYPE to 1, this means that this is an ELECTIVEORDINARY admission. The syntax commands if ADMIMETHTYPE is equal to 81 then update ADMMETHTYPE to 1, this means that this is an ELECTIVEORDINARY admission. The syntax commands if ADMIMETHTYPE is equal to 1 and CLASS PAT is equal to 2 then update ADMMETHTYPE to 2; this means that this is an ELECTIVEDAYCASE admission. The syntax commands if ADMIMETHTYPE is equal to 1 and CLASS PAT is equal to 3 and 4 then update ADMMETHTYPE to 3; this means that this is an ELECTIVEREGULAR ATTENDER admission. The syntax commands if ADMIMETHTYPE is equal to 4 then update ADMMETHTYPE to 4; this means that this is an EMERGENCY admission.

ADMISSMETHTYPE field was then deleted from dataset after this syntax was run as no longer required for analysis and ADMISSMETHTYPE retained

```
COMPUTE ADMISSMETHTYPE = 0 .
EXECUTE .

IF (ADMIMETH = 11|
ADMIMETH = 12|
ADMIMETH = 13)ADMISSMETHTYPE = 1.
EXECUTE .

IF (ADMIMETH = 21|
ADMIMETH = 22|
ADMIMETH = 23|
ADMIMETH = 24|
ADMIMETH = 28)ADMISSMETHTYPE = 4.
EXECUTE .
COMPUTE ADMMETHTYPE = 0 .
EXECUTE .

IF (ADMISSMETHTYPE= 1 &
CLASSPAT = 1) ADMMETHTYPE = 1 .
EXECUTE .

IF (ADMIMETH = 81) ADMMETHTYPE = 1 .
EXECUTE .

IF (ADMISSMETHTYPE= 1 &
CLASSPAT = 2) ADMMETHTYPE = 2 .
EXECUTE .

IF (ADMISSMETHTYPE= 1 &
CLASSPAT = 3) ADMMETHTYPE = 3 .
EXECUTE .

IF (ADMISSMETHTYPE= 1 &
CLASSPAT = 4) ADMMETHTYPE = 3 .
EXECUTE .

IF (ADMISSMETHTYPE= 4) ADMMETHTYPE = 4
.
EXECUTE .
```

## Stroke Syntax 3 – Age Band marker

```
COMPUTE AGEBAND  = 0 .
EXECUTE .

IF (ENDAGE < 21) AGEBAND
= 16 .
EXECUTE .

IF (ENDAGE < 26 & ENDAGE
>20) AGEBAND = 21 .
EXECUTE .

IF (ENDAGE < 31 & ENDAGE
>25) AGEBAND = 26 .
EXECUTE .

IF (ENDAGE < 36 & ENDAGE
>30) AGEBAND = 31 .
EXECUTE .

IF (ENDAGE < 41 & ENDAGE
>35) AGEBAND = 36 .
EXECUTE .

IF (ENDAGE < 46 & ENDAGE
>40) AGEBAND = 41 .
EXECUTE .

IF (ENDAGE < 51 & ENDAGE
>45) AGEBAND = 46 .
EXECUTE .

IF (ENDAGE < 56 & ENDAGE
>50) AGEBAND = 51 .
EXECUTE .

IF (ENDAGE < 61 & ENDAGE
>55) AGEBAND = 56 .
EXECUTE .

IF (ENDAGE < 66 & ENDAGE
>60) AGEBAND = 61 .
EXECUTE .

IF (ENDAGE < 71 & ENDAGE
>65) AGEBAND = 66 .
EXECUTE .

IF (ENDAGE < 76 & ENDAGE
>70) AGEBAND = 71 .
EXECUTE .

IF (ENDAGE < 81 & ENDAGE
>75) AGEBAND = 76 .
EXECUTE .

IF (ENDAGE < 86 & ENDAGE
>80) AGEBAND = 81 .
EXECUTE .

IF (ENDAGE > 85) AGEBAND
= 86 .
EXECUTE .
```

## Stroke Syntax 4 – Age group markers

```
COMPUTE AGEGROUP = 0.
EXECUTE.

IF (ENDAGE < 55)AGEGROUP = 1.
EXECUTE.
IF (ENDAGE > 54 & ENDAGE < 65)AGEGROUP = 2.
EXECUTE.
IF (ENDAGE > 64 & ENDAGE <75)AGEGROUP = 3.
EXECUTE.
IF (ENDAGE >74 & ENDAGE <85)AGEGROUP = 4.
EXECUTE.
IF (ENDAGE >84)AGEGROUP = 5.
EXECUTE.
```

### Stroke Syntax 5 – Emergency admission marker

```
COMPUTE EMERGENCYMARKER = 0.

EXECUTE.

IF (ADMIMETH = 21|
ADMIMETH = 22|
ADMIMETH = 23|
ADMIMETH = 24|
ADMIMETH = 28)EMERGENCYMARKER = 1.
EXECUTE.
```

### Stroke Syntax 6 – Died in admission spell

```
COMPUTE DIEDINSPELL = 0.
EXECUTE.

IF (DISMETH = 4|
DISDEST = 79)DIEDINSPELL = 1.
EXECUTE.
```

### Stroke Syntax 7 – Death marker (all)

```
COMPUTE DEATHMARKERALL = 0.
EXECUTE.

IF (DIEDINSPELL = 1|
DODMINUSADMDATE < 50000)DEATHMARKERALL = 1.
EXECUTE.
```

### Stroke Syntax 8 – Death within 7 days of admission

```
 COMPUTE DIED7DAYS = 0.
EXECUTE.

IF (DODMINUSADMDATE < 8)DIED7DAYS = 1.
EXECUTE.
```

This syntax can be amended to create markers for death within any number of days of stroke admission.

## Stroke Syntax 9 – Discharge Type

```
COMPUTE DISCHARGE = 3.

EXECUTE.

IF (DISDEST = 79)DISCHARGE = 4.
EXECUTE.

IF (DISDEST = 54|
DISDEST = 65|
DISDEST = 85|
DISDEST = 87|
DISDEST = 88)DISCHARGE = 2.
EXECUTE.

IF (DISDEST = 19)DISCHARGE = 1.
EXECUTE.
```

## Stroke Syntax 10 – Transfer from another provider as emergency

```
COMPUTE TRANSFINASEMERGENCYOTHERPROV = 0.
EXECUTE.

IF (ADMIMETH = 28)TRANSFINASEMERGENCYOTHERPROV = 1.

EXECUTE.
```

## Stroke Syntax 11 – London SHA

```
COMPUTE LONDONSHA = 0.

EXECUTE.

IF (PROCODE = 'RAL'|
PROCODE = 'RJ1'|
PROCODE = 'RJ7'|
PROCODE = 'RJZ'|
PROCODE = 'RNJ'|
PROCODE = 'RVR'|
PROCODE = 'RYJ'|
PROCODE = 'RAP'|
PROCODE = 'RF4'|
PROCODE = 'RGC'|
PROCODE = 'RAS'|
PROCODE = 'RAX'|
PROCODE = 'RC3'|
PROCODE = 'RFW'|
PROCODE = 'RG2'|
PROCODE = 'RG3'|
PROCODE = 'RGZ'|
PROCODE = 'RJ2'|
PROCODE = 'RJ6'|
PROCODE = 'RKE'|
PROCODE = 'RNH'|
PROCODE = 'RQM'|
PROCODE = 'RQX'|
PROCODE = 'RRV'|
PROCODE = 'RV8'|
PROCODE = 'RVL')LONDONSHA = 1.
EXECUTE
```

### Stroke Syntax 12 – Male gender marker for calculations

```
COMPUTE MALE = 0.
EXECUTE.

IF (SEX = 1)MALE = 1.
EXECUTE.
```

### Stroke Syntax 13 – Over 75 years old marker for calculations

```
COMPUTE OVER75 = 0.
EXECUTE.

IF (ENDAGE > 75)OVER75 = 1.
EXECUTE.
```

### Stroke Syntax 14 – PEG procedure code position marker

```
COMPUTE PEGPRC1 = 0.

EXECUTE.

IF (OPERTN1 = 'G341'|
OPERTN1 = 'G342' |
OPERTN1 = 'G343' |
OPERTN1 = 'G344' |
OPERTN1 = 'G345' |
OPERTN1 = 'G348' |
OPERTN1 = 'G349' |
OPERTN1 = 'G361' |
OPERTN1 = 'G363' |
OPERTN1 = 'G368' |
OPERTN1 = 'G369' |
OPERTN1 =
'G445')PEGPRC1 = 1.
EXECUTE.

COMPUTE PEGPRC2 = 0.
EXECUTE.

IF (OPERTN2 = 'G341'|
OPERTN2 = 'G342' |
OPERTN2 = 'G343' |
OPERTN2 = 'G344' |
OPERTN2 = 'G345' |
OPERTN2 = 'G348' |
OPERTN2 = 'G349' |
OPERTN2 = 'G361' |
OPERTN2 = 'G363' |
OPERTN2 = 'G368' |
OPERTN2 = 'G369' |
OPERTN2 =
'G445')PEGPRC2 = 1.
EXECUTE.

COMPUTE PEGPRC3 = 0.
EXECUTE.

IF (OPERTN3 = 'G341'|
OPERTN3 = 'G342' |
OPERTN3 = 'G343' |
OPERTN3 = 'G344' |
OPERTN3 = 'G345' |
OPERTN3 = 'G348' |
OPERTN3 = 'G349' |
OPERTN3 = 'G361' |
OPERTN3 = 'G363' |
OPERTN3 = 'G368' |
OPERTN3 = 'G369' |
OPERTN3 =
'G445')PEGPRC3 = 1.
EXECUTE.

COMPUTE PEGPRC4 = 0.
EXECUTE.

IF (OPERTN4 = 'G341'|
OPERTN4 = 'G342' |
OPERTN4 = 'G343' |
OPERTN4 = 'G344' |
OPERTN4 = 'G345' |
OPERTN4 = 'G348' |
OPERTN4 = 'G349' |
OPERTN4 = 'G361' |
OPERTN4 = 'G363' |
OPERTN4 = 'G368' |
OPERTN4 = 'G369' |
OPERTN4 =
'G445')PEGPRC4 = 1.
EXECUTE.

COMPUTE PEGPRC5 = 0.
EXECUTE.

IF (OPERTN5 = 'G341'|
OPERTN5 = 'G342' |
OPERTN5 = 'G343' |
OPERTN5 = 'G344' |
OPERTN5 = 'G345' |
OPERTN5 = 'G348' |
OPERTN5 = 'G349' |
OPERTN5 = 'G361' |
OPERTN5 = 'G363' |
OPERTN5 = 'G368' |
OPERTN5 = 'G369' |
OPERTN5 =
'G445')PEGPRC5 = 1.
EXECUTE.

COMPUTE PEGPRC6 = 0.
EXECUTE.

IF (OPERTN6 = 'G341'|
OPERTN6 = 'G342' |
```

```
OPERTN6 = 'G343' |
OPERTN6 = 'G344' |
OPERTN6 = 'G345' |
OPERTN6 = 'G348' |
OPERTN6 = 'G349' |
OPERTN6 = 'G361' |
OPERTN6 = 'G363' |
OPERTN6 = 'G368' |
OPERTN6 = 'G369' |
OPERTN6 =
'G445')PEGPRC6 = 1.
EXECUTE.

COMPUTE PEGPRC7 = 0.
EXECUTE.

IF (OPERTN7 = 'G341'|
OPERTN7 = 'G342' |
OPERTN7 = 'G343' |
OPERTN7 = 'G344' |
OPERTN7 = 'G345' |
OPERTN7 = 'G348' |
OPERTN7 = 'G349' |
OPERTN7 = 'G361' |
OPERTN7 = 'G363' |
OPERTN7 = 'G368' |
OPERTN7 = 'G369' |
OPERTN7 =
'G445')PEGPRC7 = 1.
EXECUTE.

COMPUTE PEGPRC8 = 0.
EXECUTE.

IF (OPERTN8 = 'G341'|
OPERTN8 = 'G342' |
OPERTN8 = 'G343' |
OPERTN8 = 'G344' |
OPERTN8 = 'G345' |
OPERTN8 = 'G348' |
OPERTN8 = 'G349' |
OPERTN8 = 'G361' |
OPERTN8 = 'G363' |
OPERTN8 = 'G368' |
OPERTN8 = 'G369' |
OPERTN8 =
'G445')PEGPRC8 = 1.
EXECUTE.

COMPUTE PEGPRC9 = 0 .
EXECUTE.

IF (OPERTN9 = 'G341'|
OPERTN9 = 'G342' |
OPERTN9 = 'G343' |
OPERTN9 = 'G344' |
OPERTN9 = 'G345' |
OPERTN9 = 'G348' |
OPERTN9 = 'G349' |
OPERTN9 = 'G361' |
OPERTN9 = 'G363' |
OPERTN9 = 'G368' |
OPERTN9 = 'G369' |
OPERTN9 =
'G445')PEGPRC9 = 1.
EXECUTE.

COMPUTE PEGPRC10 = 0 .
EXECUTE.

IF (OPERTN10 = 'G341'|
OPERTN10 = 'G342' |
OPERTN10 = 'G343' |
OPERTN10 = 'G344' |
OPERTN10 = 'G345' |
OPERTN10 = 'G348' |
OPERTN10 = 'G349' |
OPERTN10 = 'G361' |
OPERTN10 = 'G363' |
OPERTN10 = 'G368' |
OPERTN10 = 'G369' |
OPERTN10 =
'G445')PEGPRC10 = 1.
EXECUTE.

COMPUTE PEGPRC11 = 0 .
EXECUTE.

IF (OPERTN11 = 'G341'|
OPERTN11 = 'G342' |
OPERTN11 = 'G343' |
OPERTN11 = 'G344' |
OPERTN11 = 'G345' |
OPERTN11 = 'G348' |
OPERTN11 = 'G349' |
OPERTN11 = 'G361' |
OPERTN11 = 'G363' |
OPERTN11 = 'G368' |
OPERTN11 = 'G369' |
OPERTN11 =
'G445')PEGPRC11 = 1.
EXECUTE.

COMPUTE PEGPRC12 = 0 .
EXECUTE.

IF (OPERTN12 = 'G341'|
OPERTN12 = 'G342' |
OPERTN12 = 'G343' |
OPERTN12 = 'G344' |
OPERTN12 = 'G345' |
OPERTN12 = 'G348' |
OPERTN12 = 'G349' |
OPERTN12 = 'G361' |
OPERTN12 = 'G363' |
OPERTN12 = 'G368' |
OPERTN12 = 'G369' |
OPERTN12 =
'G445')PEGPRC12 = 1.
EXECUTE.

COMPUTE PEGPRC13 = 0 .
EXECUTE.

IF (OPERTN13 = 'G341'|
OPERTN13 = 'G342' |
OPERTN13 = 'G343' |
OPERTN13 = 'G344' |
OPERTN13 = 'G345' |
OPERTN13 = 'G348' |
OPERTN13 = 'G349' |
OPERTN13 = 'G361' |
OPERTN13 = 'G363' |
OPERTN13 = 'G368' |
OPERTN13 = 'G369' |
OPERTN13 =
'G445')PEGPRC13 = 1.
EXECUTE.

COMPUTE PEGPRC14 = 0.
EXECUTE.

IF (OPERTN14 = 'G341'|
OPERTN14 = 'G342' |
OPERTN14 = 'G343' |
OPERTN14 = 'G344' |
OPERTN14 = 'G345' |
OPERTN14 = 'G348' |
OPERTN14 = 'G349' |
OPERTN14 = 'G361' |
OPERTN14 = 'G363' |
OPERTN14 = 'G368' |
OPERTN14 = 'G369' |
OPERTN14 =
'G445')PEGPRC14 = 1.
EXECUTE.

COMPUTE PEGPRESENT =
0.
EXECUTE.

IF (PEGPRC1 = 1|
PEGPRC2 = 1|
PEGPRC3 = 1|
PEGPRC4 = 1|
PEGPRC5 = 1|
PEGPRC6 = 1|
PEGPRC7 = 1|
PEGPRC8 = 1|
PEGPRC9 = 1|
PEGPRC10 = 1|
```

PEGPRC11 = 1| PEGPRC14 = 1)PEGPRESENT
PEGPRC12 = 1| = 1.
PEGPRC13 = 1| EXECUTE

## Stroke Syntax 15 – Comorbidity Score

COMPUTE COMORBIDITY1 = 0.
EXECUTE.

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IF (DIAG01 = 'C000'|DIAG01 = 'C001'|DIAG01 = 'C002'|DIAG01 = 'C003'|DIAG01 = 'C004'|DIAG01 = 'C005'|DIAG01 = 'C006'|DIAG01 = 'C008'|DIAG01 = 'C009'|DIAG01 = 'C01X'|DIAG01 = 'C020'|DIAG01 = 'C021'|DIAG01 = 'C022'|DIAG01 = 'C023'|DIAG01 = 'C024'|DIAG01 = 'C028'|DIAG01 = 'C029'|DIAG01 = 'C030'|DIAG01 = 'C031'|DIAG01 = 'C039'|DIAG01 = 'C040'|DIAG01 = 'C041'|DIAG01 = 'C048'|DIAG01 = 'C049'|DIAG01 = 'C050'|DIAG01 = 'C051'|DIAG01 = 'C052'|DIAG01 = 'C058'|DIAG01 = 'C059'|DIAG01 = 'C060'|DIAG01 = 'C061'|DIAG01 = 'C062'|DIAG01 = 'C068'|DIAG01 = 'C069'|DIAG01 = 'C07X'|DIAG01 = 'C080'|DIAG01 = 'C081'|DIAG01 = 'C088'|DIAG01 = 'C089'|DIAG01 = 'C090'|DIAG01 = 'C091'|DIAG01 = 'C098'|DIAG01 = 'C099'|DIAG01 = 'C100'|DIAG01 = 'C101'|DIAG01 = 'C102'|DIAG01 = 'C103'|DIAG01 = 'C104'|DIAG01 = 'C108'|DIAG01 = 'C109'|DIAG01 = 'C110'|DIAG01 = 'C111'|DIAG01 = 'C112'|DIAG01 = 'C113'|DIAG01 = 'C118'|DIAG01 = 'C119'|DIAG01 = 'C12X'|DIAG01 = 'C130'|DIAG01 = 'C131'|DIAG01 = 'C132'|DIAG01 = 'C138'|DIAG01 = 'C139'|DIAG01 = 'C140'|DIAG01 = 'C142'|DIAG01 = 'C148'|DIAG01 = 'C150'|DIAG01 = 'C151'|DIAG01 = 'C152'|DIAG01 = 'C153'|DIAG01 = 'C154'|DIAG01 = 'C155'|DIAG01 = 'C158'|DIAG01 = 'C159'|DIAG01 = 'C160'|DIAG01 = 'C161'|DIAG01 = 'C162'|DIAG01 = 'C163'|DIAG01 = 'C164'|DIAG01 = 'C165'|DIAG01 = 'C166'|DIAG01 = 'C168'|DIAG01 = 'C169'|DIAG01 = 'C170'|DIAG01 =

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'C402'|DIAG01 = 'C403'|DIAG01 = 'C408'|DIAG01 = 'C409'|DIAG01 = 'C410'|DIAG01 = 'C411'|DIAG01 =
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'C431'|DIAG01 = 'C432'|DIAG01 = 'C433'|DIAG01 = 'C434'|DIAG01 = 'C435'|DIAG01 = 'C436'|DIAG01 =
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'C538'|DIAG01 = 'C539'|DIAG01 = 'C540'|DIAG01 = 'C541'|DIAG01 = 'C542'|DIAG01 = 'C543'|DIAG01 =
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'C632'|DIAG01 = 'C637'|DIAG01 = 'C638'|DIAG01 = 'C639'|DIAG01 = 'C64X'|DIAG01 = 'C65X'|DIAG01 =
'C66X'|DIAG01 = 'C670'|DIAG01 = 'C671'|DIAG01 = 'C672'|DIAG01 = 'C673'|DIAG01 = 'C674'|DIAG01 =
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'C681'|DIAG01 = 'C688'|DIAG01 = 'C689'|DIAG01 = 'C690'|DIAG01 = 'C691'|DIAG01 = 'C692'|DIAG01 =
'C693'|DIAG01 = 'C694'|DIAG01 = 'C695'|DIAG01 = 'C696'|DIAG01 = 'C698'|DIAG01 = 'C699'|DIAG01 =
'C700'|DIAG01 = 'C701'|DIAG01 = 'C709'|DIAG01 = 'C710'|DIAG01 = 'C711'|DIAG01 = 'C712'|DIAG01 =
'C713'|DIAG01 = 'C714'|DIAG01 = 'C715'|DIAG01 = 'C716'|DIAG01 = 'C717'|DIAG01 = 'C718'|DIAG01 =
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'C725'|DIAG01 = 'C728'|DIAG01 = 'C729'|DIAG01 = 'C73X'|DIAG01 = 'C740'|DIAG01 = 'C741'|DIAG01 =
'C749'|DIAG01 = 'C750'|DIAG01 = 'C751'|DIAG01 = 'C752'|DIAG01 = 'C753'|DIAG01 = 'C754'|DIAG01 =
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'C763'|DIAG01 = 'C764'|DIAG01 = 'C765'|DIAG01 = 'C767'|DIAG01 = 'C768'|DIAG01 = 'C810'|DIAG01 =
'C811'|DIAG01 = 'C812'|DIAG01 = 'C813'|DIAG01 = 'C817'|DIAG01 = 'C819'|DIAG01 = 'C820'|DIAG01 =
'C821'|DIAG01 = 'C822'|DIAG01 = 'C827'|DIAG01 = 'C829'|DIAG01 = 'C830'|DIAG01 = 'C831'|DIAG01 =
'C832'|DIAG01 = 'C833'|DIAG01 = 'C834'|DIAG01 = 'C835'|DIAG01 = 'C836'|DIAG01 = 'C837'|DIAG01 =
'C838'|DIAG01 = 'C839'|DIAG01 = 'C840'|DIAG01 = 'C841'|DIAG01 = 'C842'|DIAG01 = 'C843'|DIAG01 =
'C844'|DIAG01 = 'C845'|DIAG01 = 'C850'|DIAG01 = 'C851'|DIAG01 = 'C857'|DIAG01 = 'C859'|DIAG01 =
'C883'|DIAG01 = 'C887'|DIAG01 = 'C889'|DIAG01 = 'C900'|DIAG01 = 'C901'|DIAG01 = 'C910'|DIAG01 =
'C911'|DIAG01 = 'C912'|DIAG01 = 'C913'|DIAG01 = 'C914'|DIAG01 = 'C915'|DIAG01 = 'C917'|DIAG01 =
'C919'|DIAG01 = 'C920'|DIAG01 = 'C921'|DIAG01 = 'C922'|DIAG01 = 'C923'|DIAG01 = 'C924'|DIAG01 =
'C925'|DIAG01 = 'C927'|DIAG01 = 'C929'|DIAG01 = 'C930'|DIAG01 = 'C931'|DIAG01 = 'C932'|DIAG01 =
'C937'|DIAG01 = 'C939'|DIAG01 = 'C940'|DIAG01 = 'C941'|DIAG01 = 'C942'|DIAG01 = 'C943'|DIAG01 =
'C945'|DIAG01 = 'C947'|DIAG01 = 'C950'|DIAG01 = 'C951'|DIAG01 = 'C952'|DIAG01 = 'C957'|DIAG01 =
'C959'|DIAG01 = 'C960'|DIAG01 = 'C961'|DIAG01 = 'C962'|DIAG01 = 'C963'|DIAG01 = 'C967'|DIAG01 =
'C969'|DIAG01 = 'E102'|DIAG01 = 'E103'|DIAG01 = 'E104'|DIAG01 = 'E112'|DIAG01 = 'E113'|DIAG01 =
'E114'|DIAG01 = 'E132'|DIAG01 = 'E133'|DIAG01 = 'E134'|DIAG01 = 'E142'|DIAG01 = 'E143'|DIAG01 =
'E144'|DIAG01 = 'G041'|DIAG01 = 'G820'|DIAG01 = 'G821'|DIAG01 = 'G822'|DIAG01 = 'N010'|DIAG01 =
'N011'|DIAG01 = 'N012'|DIAG01 = 'N013'|DIAG01 = 'N014'|DIAG01 = 'N015'|DIAG01 = 'N016'|DIAG01 =
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'N052'|DIAG01 = 'N053'|DIAG01 = 'N054'|DIAG01 = 'N055'|DIAG01 = 'N056'|DIAG01 = 'N072'|DIAG01 =
'N073'|DIAG01 = 'N074'|DIAG01 = 'N180'|DIAG01 = 'N188'|DIAG01 = 'N189'|DIAG01 = 'N19X'|DIAG01 =
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EXECUTE.

IF (DIAG01 = 'C770'|DIAG01 = 'C771'|DIAG01 = 'C772'|DIAG01 = 'C773'|DIAG01 = 'C774'|DIAG01 =
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'K766'|DIAG01 = 'K767')COMORBIDITY1 = 3.
EXECUTE.

IF (DIAG01 = 'B200'|DIAG01 = 'B201'|DIAG01 = 'B202'|DIAG01 = 'B203'|DIAG01 = 'B204'|DIAG01 =
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'B211'|DIAG01 = 'B212'|DIAG01 = 'B213'|DIAG01 = 'B217'|DIAG01 = 'B218'|DIAG01 = 'B219'|DIAG01 =
'B220'|DIAG01 = 'B221'|DIAG01 = 'B222'|DIAG01 = 'B227'|DIAG01 = 'B230'|DIAG01 = 'B231'|DIAG01 =
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EXECUTE.

COMPUTE COMORBIDITY2 = 0.
EXECUTE.

IF (DIAG02 = 'E101'|DIAG02 = 'E105'|DIAG02 = 'E109'|DIAG02 = 'E111'|DIAG02 = 'E115'|DIAG02 =
'E119'|DIAG02 = 'E131'|DIAG02 = 'E135'|DIAG02 = 'E139'|DIAG02 = 'E141'|DIAG02 = 'E145'|DIAG02 =
'E149'|DIAG02 = 'F000'|DIAG02 = 'F001'|DIAG02 = 'F002'|DIAG02 = 'F009'|DIAG02 = 'F010'|DIAG02 =
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'F021'|DIAG02 = 'F022'|DIAG02 = 'F023'|DIAG02 = 'F024'|DIAG02 = 'F028'|DIAG02 = 'F051'|DIAG02 =
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'I221'|DIAG02 = 'I228'|DIAG02 = 'I229'|DIAG02 = 'I252'|DIAG02 = 'I500'|DIAG02 = 'I501'|DIAG02 =
'I509'|DIAG02 = 'I601'|DIAG02 = 'I602'|DIAG02 = 'I603'|DIAG02 = 'I604'|DIAG02 = 'I605'|DIAG02 =
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'I671'|DIAG02 = 'I674'|DIAG02 = 'I675'|DIAG02 = 'I676'|DIAG02 = 'I677'|DIAG02 = 'I681'|DIAG02 =
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'K281'|DIAG02 = 'K282'|DIAG02 = 'K283'|DIAG02 = 'K284'|DIAG02 = 'K285'|DIAG02 = 'K286'|DIAG02 =
'K287'|DIAG02 = 'K289'|DIAG02 = 'K702'|DIAG02 = 'K703'|DIAG02 = 'K717'|DIAG02 = 'K731'|DIAG02 =
'K732'|DIAG02 = 'K738'|DIAG02 = 'K739'|DIAG02 = 'K740'|DIAG02 = 'K742'|DIAG02 = 'K743'|DIAG02 =
'K744'|DIAG02 = 'K745'|DIAG02 = 'K746'|DIAG02 = 'M050'|DIAG02 = 'M051'|DIAG02 = 'M052'|DIAG02 =
'M053'|DIAG02 = 'M058'|DIAG02 = 'M059'|DIAG02 = 'M060'|DIAG02 = 'M063'|DIAG02 = 'M069'|DIAG02 =
'M320'|DIAG02 = 'M321'|DIAG02 = 'M328'|DIAG02 = 'M329'|DIAG02 = 'M332'|DIAG02 = 'M340'|DIAG02 =
'M341'|DIAG02 = 'M342'|DIAG02 = 'M348'|DIAG02 = 'M349'|DIAG02 = 'M353'|DIAG02 = 'R02X'|DIAG02 =
'Z958'|DIAG02 = 'Z959')COMORBIDITY2 = 1.
EXECUTE.

IF (DIAG02 = 'C000'|DIAG02 = 'C001'|DIAG02 = 'C002'|DIAG02 = 'C003'|DIAG02 = 'C004'|DIAG02 =
'C005'|DIAG02 = 'C006'|DIAG02 = 'C008'|DIAG02 = 'C009'|DIAG02 = 'C01X'|DIAG02 = 'C020'|DIAG02 =
'C021'|DIAG02 = 'C022'|DIAG02 = 'C023'|DIAG02 = 'C024'|DIAG02 = 'C028'|DIAG02 = 'C029'|DIAG02 =
'C030'|DIAG02 = 'C031'|DIAG02 = 'C039'|DIAG02 = 'C040'|DIAG02 = 'C041'|DIAG02 = 'C048'|DIAG02 =
'C049'|DIAG02 = 'C050'|DIAG02 = 'C051'|DIAG02 = 'C052'|DIAG02 = 'C058'|DIAG02 = 'C059'|DIAG02 =
'C060'|DIAG02 = 'C061'|DIAG02 = 'C062'|DIAG02 = 'C068'|DIAG02 = 'C069'|DIAG02 = 'C07X'|DIAG02 =
'C080'|DIAG02 = 'C081'|DIAG02 = 'C088'|DIAG02 = 'C089'|DIAG02 = 'C090'|DIAG02 = 'C091'|DIAG02 =
'C098'|DIAG02 = 'C099'|DIAG02 = 'C100'|DIAG02 = 'C101'|DIAG02 = 'C102'|DIAG02 = 'C103'|DIAG02 =
'C104'|DIAG02 = 'C108'|DIAG02 = 'C109'|DIAG02 = 'C110'|DIAG02 = 'C111'|DIAG02 = 'C112'|DIAG02 =
```

'C113'|DIAG02 = 'C118'|DIAG02 = 'C119'|DIAG02 = 'C12X'|DIAG02 = 'C130'|DIAG02 = 'C131'|DIAG02 =
'C132'|DIAG02 = 'C138'|DIAG02 = 'C139'|DIAG02 = 'C140'|DIAG02 = 'C142'|DIAG02 = 'C148'|DIAG02 =
'C150'|DIAG02 = 'C151'|DIAG02 = 'C152'|DIAG02 = 'C153'|DIAG02 = 'C154'|DIAG02 = 'C155'|DIAG02 =
'C158'|DIAG02 = 'C159'|DIAG02 = 'C160'|DIAG02 = 'C161'|DIAG02 = 'C162'|DIAG02 = 'C163'|DIAG02 =
'C164'|DIAG02 = 'C165'|DIAG02 = 'C166'|DIAG02 = 'C168'|DIAG02 = 'C169'|DIAG02 = 'C170'|DIAG02 =
'C171'|DIAG02 = 'C172'|DIAG02 = 'C173'|DIAG02 = 'C178'|DIAG02 = 'C179'|DIAG02 = 'C180'|DIAG02 =
'C181'|DIAG02 = 'C182'|DIAG02 = 'C183'|DIAG02 = 'C184'|DIAG02 = 'C185'|DIAG02 = 'C186'|DIAG02 =
'C187'|DIAG02 = 'C188'|DIAG02 = 'C189'|DIAG02 = 'C19X'|DIAG02 = 'C20X'|DIAG02 = 'C210'|DIAG02 =
'C211'|DIAG02 = 'C212'|DIAG02 = 'C218'|DIAG02 = 'C220'|DIAG02 = 'C221'|DIAG02 = 'C222'|DIAG02 =
'C223'|DIAG02 = 'C224'|DIAG02 = 'C227'|DIAG02 = 'C229'|DIAG02 = 'C23X'|DIAG02 = 'C240'|DIAG02 =
'C241'|DIAG02 = 'C248'|DIAG02 = 'C249'|DIAG02 = 'C250'|DIAG02 = 'C251'|DIAG02 = 'C252'|DIAG02 =
'C253'|DIAG02 = 'C254'|DIAG02 = 'C257'|DIAG02 = 'C258'|DIAG02 = 'C259'|DIAG02 = 'C260'|DIAG02 =
'C261'|DIAG02 = 'C268'|DIAG02 = 'C269'|DIAG02 = 'C300'|DIAG02 = 'C301'|DIAG02 = 'C310'|DIAG02 =
'C311'|DIAG02 = 'C312'|DIAG02 = 'C313'|DIAG02 = 'C318'|DIAG02 = 'C319'|DIAG02 = 'C320'|DIAG02 =
'C321'|DIAG02 = 'C322'|DIAG02 = 'C323'|DIAG02 = 'C328'|DIAG02 = 'C329'|DIAG02 = 'C33X'|DIAG02 =
'C340'|DIAG02 = 'C341'|DIAG02 = 'C342'|DIAG02 = 'C343'|DIAG02 = 'C348'|DIAG02 = 'C349'|DIAG02 =
'C37X'|DIAG02 = 'C380'|DIAG02 = 'C381'|DIAG02 = 'C382'|DIAG02 = 'C383'|DIAG02 = 'C384'|DIAG02 =
'C388'|DIAG02 = 'C390'|DIAG02 = 'C398'|DIAG02 = 'C399'|DIAG02 = 'C400'|DIAG02 = 'C401'|DIAG02 =
'C402'|DIAG02 = 'C403'|DIAG02 = 'C408'|DIAG02 = 'C409'|DIAG02 = 'C410'|DIAG02 = 'C411'|DIAG02 =
'C412'|DIAG02 = 'C413'|DIAG02 = 'C414'|DIAG02 = 'C418'|DIAG02 = 'C419'|DIAG02 = 'C430'|DIAG02 =
'C431'|DIAG02 = 'C432'|DIAG02 = 'C433'|DIAG02 = 'C434'|DIAG02 = 'C435'|DIAG02 = 'C436'|DIAG02 =
'C437'|DIAG02 = 'C438'|DIAG02 = 'C439'|DIAG02 = 'C450'|DIAG02 = 'C451'|DIAG02 = 'C452'|DIAG02 =
'C457'|DIAG02 = 'C459'|DIAG02 = 'C460'|DIAG02 = 'C461'|DIAG02 = 'C462'|DIAG02 = 'C463'|DIAG02 =
'C467'|DIAG02 = 'C468'|DIAG02 = 'C469'|DIAG02 = 'C470'|DIAG02 = 'C471'|DIAG02 = 'C472'|DIAG02 =
'C473'|DIAG02 = 'C474'|DIAG02 = 'C475'|DIAG02 = 'C476'|DIAG02 = 'C478'|DIAG02 = 'C479'|DIAG02 =
'C480'|DIAG02 = 'C481'|DIAG02 = 'C482'|DIAG02 = 'C488'|DIAG02 = 'C490'|DIAG02 = 'C491'|DIAG02 =
'C492'|DIAG02 = 'C493'|DIAG02 = 'C494'|DIAG02 = 'C495'|DIAG02 = 'C496'|DIAG02 = 'C498'|DIAG02 =
'C499'|DIAG02 = 'C500'|DIAG02 = 'C501'|DIAG02 = 'C502'|DIAG02 = 'C503'|DIAG02 = 'C504'|DIAG02 =
'C505'|DIAG02 = 'C506'|DIAG02 = 'C508'|DIAG02 = 'C509'|DIAG02 = 'C510'|DIAG02 = 'C511'|DIAG02 =
'C512'|DIAG02 = 'C518'|DIAG02 = 'C519'|DIAG02 = 'C52X'|DIAG02 = 'C530'|DIAG02 = 'C531'|DIAG02 =
'C538'|DIAG02 = 'C539'|DIAG02 = 'C540'|DIAG02 = 'C541'|DIAG02 = 'C542'|DIAG02 = 'C543'|DIAG02 =
'C548'|DIAG02 = 'C549'|DIAG02 = 'C55X'|DIAG02 = 'C56X'|DIAG02 = 'C570'|DIAG02 = 'C571'|DIAG02 =
'C572'|DIAG02 = 'C573'|DIAG02 = 'C574'|DIAG02 = 'C577'|DIAG02 = 'C578'|DIAG02 = 'C579'|DIAG02 =
'C58X'|DIAG02 = 'C600'|DIAG02 = 'C601'|DIAG02 = 'C602'|DIAG02 = 'C608'|DIAG02 = 'C609'|DIAG02 =
'C61X'|DIAG02 = 'C620'|DIAG02 = 'C621'|DIAG02 = 'C629'|DIAG02 = 'C630'|DIAG02 = 'C631'|DIAG02 =
'C632'|DIAG02 = 'C637'|DIAG02 = 'C638'|DIAG02 = 'C639'|DIAG02 = 'C64X'|DIAG02 = 'C65X'|DIAG02 =
'C66X'|DIAG02 = 'C670'|DIAG02 = 'C671'|DIAG02 = 'C672'|DIAG02 = 'C673'|DIAG02 = 'C674'|DIAG02 =
'C675'|DIAG02 = 'C676'|DIAG02 = 'C677'|DIAG02 = 'C678'|DIAG02 = 'C679'|DIAG02 = 'C680'|DIAG02 =
'C681'|DIAG02 = 'C688'|DIAG02 = 'C689'|DIAG02 = 'C690'|DIAG02 = 'C691'|DIAG02 = 'C692'|DIAG02 =
'C693'|DIAG02 = 'C694'|DIAG02 = 'C695'|DIAG02 = 'C696'|DIAG02 = 'C698'|DIAG02 = 'C699'|DIAG02 =
'C700'|DIAG02 = 'C701'|DIAG02 = 'C709'|DIAG02 = 'C710'|DIAG02 = 'C711'|DIAG02 = 'C712'|DIAG02 =
'C713'|DIAG02 = 'C714'|DIAG02 = 'C715'|DIAG02 = 'C716'|DIAG02 = 'C717'|DIAG02 = 'C718'|DIAG02 =
'C719'|DIAG02 = 'C720'|DIAG02 = 'C721'|DIAG02 = 'C722'|DIAG02 = 'C723'|DIAG02 = 'C724'|DIAG02 =
'C725'|DIAG02 = 'C728'|DIAG02 = 'C729'|DIAG02 = 'C73X'|DIAG02 = 'C740'|DIAG02 = 'C741'|DIAG02 =
'C749'|DIAG02 = 'C750'|DIAG02 = 'C751'|DIAG02 = 'C752'|DIAG02 = 'C753'|DIAG02 = 'C754'|DIAG02 =
'C755'|DIAG02 = 'C758'|DIAG02 = 'C759'|DIAG02 = 'C760'|DIAG02 = 'C761'|DIAG02 = 'C762'|DIAG02 =
'C763'|DIAG02 = 'C764'|DIAG02 = 'C765'|DIAG02 = 'C767'|DIAG02 = 'C768'|DIAG02 = 'C810'|DIAG02 =
'C811'|DIAG02 = 'C812'|DIAG02 = 'C813'|DIAG02 = 'C817'|DIAG02 = 'C819'|DIAG02 = 'C820'|DIAG02 =
'C821'|DIAG02 = 'C822'|DIAG02 = 'C827'|DIAG02 = 'C829'|DIAG02 = 'C830'|DIAG02 = 'C831'|DIAG02 =
'C832'|DIAG02 = 'C833'|DIAG02 = 'C834'|DIAG02 = 'C835'|DIAG02 = 'C836'|DIAG02 = 'C837'|DIAG02 =
'C838'|DIAG02 = 'C839'|DIAG02 = 'C840'|DIAG02 = 'C841'|DIAG02 = 'C842'|DIAG02 = 'C843'|DIAG02 =
'C844'|DIAG02 = 'C845'|DIAG02 = 'C850'|DIAG02 = 'C851'|DIAG02 = 'C857'|DIAG02 = 'C859'|DIAG02 =
'C883'|DIAG02 = 'C887'|DIAG02 = 'C889'|DIAG02 = 'C900'|DIAG02 = 'C901'|DIAG02 = 'C910'|DIAG02 =
'C911'|DIAG02 = 'C912'|DIAG02 = 'C913'|DIAG02 = 'C914'|DIAG02 = 'C915'|DIAG02 = 'C917'|DIAG02 =
'C919'|DIAG02 = 'C920'|DIAG02 = 'C921'|DIAG02 = 'C922'|DIAG02 = 'C923'|DIAG02 = 'C924'|DIAG02 =
'C925'|DIAG02 = 'C927'|DIAG02 = 'C929'|DIAG02 = 'C930'|DIAG02 = 'C931'|DIAG02 = 'C932'|DIAG02 =
'C937'|DIAG02 = 'C939'|DIAG02 = 'C940'|DIAG02 = 'C941'|DIAG02 = 'C942'|DIAG02 = 'C943'|DIAG02 =
'C945'|DIAG02 = 'C947'|DIAG02 = 'C950'|DIAG02 = 'C951'|DIAG02 = 'C952'|DIAG02 = 'C957'|DIAG02 =
'C959'|DIAG02 = 'C960'|DIAG02 = 'C961'|DIAG02 = 'C962'|DIAG02 = 'C963'|DIAG02 = 'C967'|DIAG02 =
'C969'|DIAG02 = 'E102'|DIAG02 = 'E103'|DIAG02 = 'E104'|DIAG02 = 'E112'|DIAG02 = 'E113'|DIAG02 =
'E114'|DIAG02 = 'E132'|DIAG02 = 'E133'|DIAG02 = 'E134'|DIAG02 = 'E142'|DIAG02 = 'E143'|DIAG02 =
'E144'|DIAG02 = 'G041'|DIAG02 = 'G820'|DIAG02 = 'G821'|DIAG02 = 'G822'|DIAG02 = 'N010'|DIAG02 =
'N011'|DIAG02 = 'N012'|DIAG02 = 'N013'|DIAG02 = 'N014'|DIAG02 = 'N015'|DIAG02 = 'N016'|DIAG02 =

```
'N017'|DIAG02 = 'N018'|DIAG02 = 'N019'|DIAG02 = 'N031'|DIAG02 = 'N032'|DIAG02 = 'N033'|DIAG02 =
'N034'|DIAG02 = 'N035'|DIAG02 = 'N036'|DIAG02 = 'N037'|DIAG02 = 'N038'|DIAG02 = 'N039'|DIAG02 =
'N052'|DIAG02 = 'N053'|DIAG02 = 'N054'|DIAG02 = 'N055'|DIAG02 = 'N056'|DIAG02 = 'N072'|DIAG02 =
'N073'|DIAG02 = 'N074'|DIAG02 = 'N180'|DIAG02 = 'N188'|DIAG02 = 'N189'|DIAG02 = 'N19X'|DIAG02 =
'N250'|DIAG02 = 'N251'|DIAG02 = 'N258'|DIAG02 = 'N259')COMORBIDITY2 = 2.
EXECUTE.

IF (DIAG02 = 'C770'|DIAG02 = 'C771'|DIAG02 = 'C772'|DIAG02 = 'C773'|DIAG02 = 'C774'|DIAG02 =
'C775'|DIAG02 = 'C778'|DIAG02 = 'C779'|DIAG02 = 'C780'|DIAG02 = 'C781'|DIAG02 = 'C782'|DIAG02 =
'C783'|DIAG02 = 'C784'|DIAG02 = 'C785'|DIAG02 = 'C786'|DIAG02 = 'C787'|DIAG02 = 'C788'|DIAG02 =
'C790'|DIAG02 = 'C791'|DIAG02 = 'C792'|DIAG02 = 'C793'|DIAG02 = 'C794'|DIAG02 = 'C795'|DIAG02 =
'C796'|DIAG02 = 'C797'|DIAG02 = 'C798'|DIAG02 = 'C80X'|DIAG02 = 'K721'|DIAG02 = 'K729'|DIAG02 =
'K766'|DIAG02 = 'K767')COMORBIDITY2 = 3.
EXECUTE.

IF (DIAG02 = 'B200'|DIAG02 = 'B201'|DIAG02 = 'B202'|DIAG02 = 'B203'|DIAG02 = 'B204'|DIAG02 =
'B205'|DIAG02 = 'B206'|DIAG02 = 'B207'|DIAG02 = 'B208'|DIAG02 = 'B209'|DIAG02 = 'B210'|DIAG02 =
'B211'|DIAG02 = 'B212'|DIAG02 = 'B213'|DIAG02 = 'B217'|DIAG02 = 'B218'|DIAG02 = 'B219'|DIAG02 =
'B220'|DIAG02 = 'B221'|DIAG02 = 'B222'|DIAG02 = 'B227'|DIAG02 = 'B230'|DIAG02 = 'B231'|DIAG02 =
'B232'|DIAG02 = 'B238'|DIAG02 = 'B24X') COMORBIDITY2 = 6.
EXECUTE.
```

Then repeat as above for ICD-10 code positions 3 through 20

## Stroke Syntax 16 – Speciality type marker

```
COMPUTE SPECTYPE = 0.
EXECUTE.

IF (MAINSPEF = 300|
MAINSPEF = 301|
MAINSPEF = 302|
MAINSPEF = 303|
MAINSPEF = 305|
MAINSPEF = 313|
MAINSPEF = 314|
MAINSPEF = 315|
MAINSPEF = 320|
MAINSPEF = 330|
MAINSPEF = 340|
MAINSPEF = 350|
MAINSPEF = 352|
MAINSPEF = 360|
MAINSPEF = 361|
MAINSPEF = 370|
MAINSPEF = 400|
MAINSPEF = 410|
MAINSPEF = 430|
MAINSPEF = 823)SPECTYPE = 1.
EXECUTE.
```

```
IF (MAINSPEF = 100|
MAINSPEF = 101|
MAINSPEF = 110|
MAINSPEF = 120|
MAINSPEF = 130|
MAINSPEF = 140|
MAINSPEF = 145|
MAINSPEF = 150|
MAINSPEF = 160|
MAINSPEF = 170|
MAINSPEF = 180|
MAINSPEF = 190|
MAINSPEF = 192)SPECTYPE = 2.
EXECUTE
```

## Stroke Syntax 17 – Comorbidity group marker

```
COMPUTE COMORBIDGRP = 0.
EXECUTE .

IF (COMORBIDTOTAL = 0)COMORBIDGRP = 1.
EXECUTE.

IF (COMORBIDTOTAL = 1)COMORBIDGRP = 2.
EXECUTE .

IF (COMORBIDTOTAL > 1)COMORBIDGRP = 3.
EXECUTE.
```

## Stroke Syntax 18 – PEG procedure performed in first stroke admission

```
COMPUTE PEGINFIRSTSTROKEADM = 2.
EXECUTE.

IF (SPELLOS = PEGDATEMINUSADMDATE|
SPELLOS > PEGDATEMINUSADMDATE)PEGINFIRSTSTROKEADM = 1.
EXECUTE.
```

## Stroke Syntax 19 – Death status 30 days after PEG procedure

```
COMPUTE ALIVEDEAD30DAYAFTERPEG = 3.
EXECUTE.

IF (NOOFDAYSFROMPEGDATETODEATHDATE < 31)ALIVEDEAD30DAYAFTERPEG = 1.
EXECUTE.

IF (NOOFDAYSFROMPEGDATETODEATHDATE > 30)ALIVEDEAD30DAYAFTERPEG = 2.
EXECUTE.
```

This can be modified to create markers for death within any number of days of PEG procedure

## Stroke Syntax 20 – Small volume Trust marker

```
COMPUTE
SMALLVOLTRUST = 0.
EXECUTE.

IF (PROCODE='RAS'|
PROCODE='RBD'|
PROCODE='RJN'|
PROCODE='RLQ'|
PROCODE='RM2'|
PROCODE='RNJ'|
PROCODE='RRV'|
PROCODE='RWJ'|
PROCODE='RA7'|
PROCODE='RM4'|
PROCODE='RTP'|
PROCODE='RWH'|
PROCODE='RBA'|
PROCODE='RCC'|
PROCODE='RCF'|
PROCODE='RJ6'|
PROCODE='RJE'|
PROCODE='RLN'|
PROCODE='RN5'|
PROCODE='RQM'|
PROCODE='RA4'|
PROCODE='RBZ'|
PROCODE='RDU'|
PROCODE='RDZ'|
PROCODE='RE9'|
PROCODE='RN3'|
PROCODE='RNH'|
PROCODE='RNZ'|
PROCODE='RPA'|
PROCODE='RPL'|
PROCODE='RQQ'|
PROCODE='RTE')SMALLVOL
TRUST = 1.
EXECUTE
```

## Stroke Syntax 21 – Discharge to Nursing Home

```
COMPUTE DISCHNURSINGHOME = 0.
EXECUTE .
IF (DISDEST = 54|
DISDEST = 65|
DISDEST = 85|
DISDEST = 87|
DISDEST = 88)DISCHNURSINGHOME = 1.
EXECUTE.
```

## Stroke Syntax 22 – Emergency readmission following stroke admission

```
COMPUTE EMERGREADMIT7DAYSOF1STSTROKE = 0.
EXECUTE.

IF (DAYSBETDISCHOF1STSTROKEANDADMOFNXTEMERGADM <
8)EMERGREADMIT7DAYSOF1STSTROKE = 1.
EXECUTE.

COMPUTE EMERGREADMIT30DAYSOF1STSTROKE = 0.
EXECUTE.

IF (DAYSBETDISCHOF1STSTROKEANDADMOFNXTEMERGADM <
31)EMERGREADMIT30DAYSOF1STSTROKE = 1.
EXECUTE.
```

## Stroke Syntax 23 – Assign 2 year dataset month tag

```
COMPUTE MONTHTAG = 0.
EXECUTE.

IF (MONTHFINANCIAL = 4)MONTHTAG = 13.
EXECUTE.

IF (MONTHFINANCIAL = 5)MONTHTAG = 14.
EXECUTE.

IF (MONTHFINANCIAL = 6)MONTHTAG = 15.
EXECUTE.

IF (MONTHFINANCIAL = 7)MONTHTAG = 16.
EXECUTE.

IF (MONTHFINANCIAL = 8)MONTHTAG = 17.
EXECUTE.

IF (MONTHFINANCIAL = 9)MONTHTAG = 18.
EXECUTE.

IF (MONTHFINANCIAL = 10)MONTHTAG = 19.
EXECUTE.

IF (MONTHFINANCIAL = 11)MONTHTAG = 20.
EXECUTE.

IF (MONTHFINANCIAL = 12)MONTHTAG = 21.
EXECUTE.

IF (MONTHFINANCIAL = 1)MONTHTAG = 22.
EXECUTE.

IF (MONTHFINANCIAL = 2)MONTHTAG = 23.
EXECUTE.

IF (MONTHFINANCIAL = 3)MONTHTAG = 24.
EXECUTE
```

## Stroke Syntax 24 – Stroke marker

```
COMPUTE MARKER = 0.
EXECUTE.

IF (STROKE > 0)MARKER = 1.
EXECUTE.
```

## Stroke Syntax 25 – PEG volume Tertiles

```
COMPUTE LOWPEGVOLTRUST
= 0.
EXECUTE.

IF(PROCODE='RCF'|
PROCODE='RA3'|
PROCODE='5QT'|
PROCODE='RGZ'|
PROCODE='RE9'|
PROCODE='RNH'|
PROCODE='RCC'|
PROCODE='RR7'|
PROCODE='RQQ'|
PROCODE='RQX'|
PROCODE='RKE'|
PROCODE='RA4'|
PROCODE='RFW'|
PROCODE='RBZ'|
PROCODE='RNZ'|
PROCODE='RJF'|
PROCODE='RVY'|
PROCODE='RPL'|
PROCODE='RC1'|
PROCODE='RN7'|
PROCODE='RJ2'|
PROCODE='RGP'|
PROCODE='RN3'|
PROCODE='RCD'|
PROCODE='RGR'|
PROCODE='RG2'|
PROCODE='RN5'|
PROCODE='RC3'|
PROCODE='RAX'|
PROCODE='RBT'|
PROCODE='RLT'|
PROCODE='RRF'|
PROCODE='RDU'|
PROCODE='RQW'|
PROCODE='RJ6'|
PROCODE='RGC'|
PROCODE='RK5'|
PROCODE='RJD'|
PROCODE='RFF'|
PROCODE='RTK'|
PROCODE='RDZ'|
PROCODE='RBA'|
PROCODE='RXL'|
PROCODE='RJC'|
PROCODE='RD8'|
PROCODE='RTF')LOWPEGVOLT
RUST = 1.
EXECUTE.

COMPUTE MEDPEGVOLTRUST
= 0.
EXECUTE.

IF(PROCODE='RN1'|
PROCODE='RAL'|
PROCODE='RA7'|
PROCODE='RGN'|
PROCODE='RM4'|
PROCODE='RVW'|
PROCODE='RBK'|
PROCODE='RA9'|
PROCODE='RBL'|
PROCODE='RPA'|
PROCODE='RWG'|
PROCODE='RJL'|
PROCODE='RNL'|
PROCODE='RWW'|
PROCODE='RG3'|
PROCODE='RMP'|
PROCODE='RD7'|
PROCODE='RF4'|
PROCODE='RCX'|
PROCODE='RTX'|
PROCODE='RFR'|
PROCODE='RQM'|
PROCODE='RWF'|
PROCODE='RXQ'|
PROCODE='RC9'|
PROCODE='RXP'|
PROCODE='RPR'|
PROCODE='RHM'|
PROCODE='RDE'|
PROCODE='RD1'|
PROCODE='RGQ'|
PROCODE='RCB'|
PROCODE='RQ8'|
PROCODE='RJR'|
PROCODE='RNA'|
PROCODE='RLN'|
PROCODE='RJ7'|
PROCODE='RNS'|
PROCODE='RNQ'|
PROCODE='RL4'|
PROCODE='RWP'|
PROCODE='RD3'|
PROCODE='RVL'|
PROCODE='RMC'|
PROCODE='RAP'|
PROCODE='RVV')MEDPEGVOL
TRUST = 1.
EXECUTE.

COMPUTE HIGHPEGVOLTRUST
= 0.
EXECUTE.

IF(PROCODE='RWD'|
PROCODE='RXK'|
PROCODE='RK9'|
PROCODE='RFS'|
PROCODE='RA2'|
PROCODE='RAJ'|
PROCODE='RW3'|
PROCODE='RXH'|
PROCODE='RHU'|
PROCODE='RR1'|
PROCODE='RH8'|
PROCODE='RXC'|
PROCODE='RKB'|
PROCODE='RVR'|
PROCODE='RQ6'|
PROCODE='RJZ'|
PROCODE='RTR'|
PROCODE='RAE'|
PROCODE='RYJ'|
PROCODE='RRK'|
PROCODE='RWY'|
PROCODE='RGT'|
PROCODE='REF'|
PROCODE='RV8'|
PROCODE='RTE'|
PROCODE='RHW'|
PROCODE='RM1'|
PROCODE='RJE'|
PROCODE='RXF'|
PROCODE='RXR'|
PROCODE='RXW'|
PROCODE='RM3'|
PROCODE='RTG'|
PROCODE='RP5'|
PROCODE='RVJ'|
PROCODE='RXN'|
PROCODE='RR8'|
PROCODE='RX1'|
PROCODE='RWE'|
PROCODE='RTH'|
PROCODE='RTD'|
PROCODE='RHQ'|
PROCODE='REM'|
PROCODE='RWA'|
PROCODE='RW6')HIGHPEGVO
LTRUST = 1.
EXECUTE.
```

## Stroke Syntax 26 – Stroke volume

**Tertiles**COMPUTE
LOWSTROKEVOLUME = 0.

EXECUTE.
IF(PROCODE='RQM'|
PROCODE='RQX'|
PROCODE='RM4'|
PROCODE='RD8'|
PROCODE='RN5'|
PROCODE='RJF'|
PROCODE='RNH'|
PROCODE='RQQ'|
PROCODE='RJC'|
PROCODE='RBZ'|
PROCODE='RKE'|
PROCODE='RC1'|
PROCODE='RGZ'|
PROCODE='RN1'|
PROCODE='RC3'|
PROCODE='RCC'|
PROCODE='RJR'|
PROCODE='RA4'|
PROCODE='RCD'|
PROCODE='RE9'|
PROCODE='RAL'|
PROCODE='RNZ'|
PROCODE='RLT'|
PROCODE='RA3'|
PROCODE='RNS'|
PROCODE='RV8'|
PROCODE='RAP'|
PROCODE='RA2'|
PROCODE='RGR'|
PROCODE='5QT'|
PROCODE='RN3'|
PROCODE='RR7'|
PROCODE='RG2'|
PROCODE='RQW'|
PROCODE='RDU'|
PROCODE='RPR'|
PROCODE='RBT'|
PROCODE='RFW'|
PROCODE='RCF'|
PROCODE='RJ2'|
PROCODE='RBK'|
PROCODE='RJZ'|
PROCODE='RMP'|
PROCODE='RW3'|
PROCODE='RG3'|
PROCODE='RGP'|
PROCODE='RTK')LOWSTRO
KEVOLUME = 1.
EXECUTE.

COMPUTE
MEDSTROKEVOLUME = 0.
EXECUTE.
IF(PROCODE='RVY'|
PROCODE='RJ6'|
PROCODE='RJD'|
PROCODE='RD3'|
PROCODE='RCX'|
PROCODE='RM3'|
PROCODE='RFS'|
PROCODE='RJ7'|
PROCODE='RA7'|
PROCODE='RPA'|
PROCODE='RBA'|
PROCODE='RFF'|
PROCODE='RC9'|
PROCODE='RA9'|
PROCODE='RD7'|
PROCODE='RN7'|
PROCODE='RNQ'|
PROCODE='RGC'|
PROCODE='RGN'|
PROCODE='RK5'|
PROCODE='RQ8'|
PROCODE='RFR'|
PROCODE='RAE'|
PROCODE='RXQ'|
PROCODE='RL4'|
PROCODE='RGQ'|
PROCODE='REM'|
PROCODE='RPL'|
PROCODE='RAX'|
PROCODE='RJE'|
PROCODE='RDZ'|
PROCODE='RRK'|
PROCODE='RNA'|
PROCODE='RMC'|
PROCODE='RVW'|
PROCODE='RTD'|
PROCODE='RWW'|
PROCODE='RHW'|
PROCODE='RGT'|
PROCODE='RTX'|
PROCODE='RAJ'|
PROCODE='RNL'|
PROCODE='RQ6'|
PROCODE='RXH')MEDSTRO
KEVOLUME = 1.
EXECUTE.

COMPUTE
HIGHSTROKEVOLUME = 0.
EXECUTE.

IF(PROCODE='RK9'|
PROCODE='RH8'|
PROCODE='RDE'|
PROCODE='RRF'|
PROCODE='RVJ'|
PROCODE='RXN'|
PROCODE='RCB'|
PROCODE='RWY'|
PROCODE='RWG'|
PROCODE='RWP'|
PROCODE='RLN'|
PROCODE='RTH'|
PROCODE='RD1'|
PROCODE='RJL'|
PROCODE='RVL'|
PROCODE='RKB'|
PROCODE='RHM'|
PROCODE='RVR'|
PROCODE='RP5'|
PROCODE='RTG'|
PROCODE='RYJ'|
PROCODE='RXW'|
PROCODE='REF'|
PROCODE='RWF'|
PROCODE='RXL'|
PROCODE='RBL'|
PROCODE='RXR'|
PROCODE='RTR'|
PROCODE='RXK'|
PROCODE='RTE'|
PROCODE='RTF'|
PROCODE='RXC'|
PROCODE='RHU'|
PROCODE='RXP'|
PROCODE='RXF'|
PROCODE='RX1'|

```
PROCODE='RWA'|
PROCODE='RM1'|
PROCODE='RF4'|
PROCODE='RWD'|
PROCODE='RR8'|
PROCODE='RVV'|
PROCODE='RHQ'|
PROCODE='RR1'|
PROCODE='RWE'|
PROCODE='RW6')HIGHSTR
OKEVOLUME = 1.
EXECUTE.
```

## Stroke Syntax 27 – SINAP score

**Tertile**

```
COMPUTE
SINAPTERTILE = 0.

EXECUTE.
IF(PROCODE='RQQ'|
PROCODE='RWP'|
PROCODE='RBT'|
PROCODE='REF'|
PROCODE='RXN'|
PROCODE='RA3'|
PROCODE='RTH'|
PROCODE='RN3'|
PROCODE='RLN'|
PROCODE='RD7'|
PROCODE='RNQ'|
PROCODE='RM1'|
PROCODE='RG3'|
PROCODE='RXF'|
PROCODE='RHU'|
PROCODE='RW3'|
PROCODE='RXW'|
PROCODE='RTX'|
PROCODE='RC1'|
PROCODE='RJL'|
PROCODE='RXR'|
PROCODE='RXL'|
PROCODE='RBZ'|
PROCODE='RGQ'|
PROCODE='RK9'|
PROCODE='RWF'|
PROCODE='RJC'|
PROCODE='RXP'|
PROCODE='RPL'|
PROCODE='RJD'|
PROCODE='RQW'|
PROCODE='RWD'|
PROCODE='RWY'|
PROCODE='RAE'|
PROCODE='RR8'|
PROCODE='5QT'|
PROCODE='RC9'|
PROCODE='RXQ'|
PROCODE='RN7'|
PROCODE='RR7'|
PROCODE='RK5'|
PROCODE='RPA'|
PROCODE='RE9'|
PROCODE='RJF'|
PROCODE='RJ6'|
PROCODE='RRK')SINAPTERT
ILE = 1.
EXECUTE.

IF(PROCODE='RGP'|
PROCODE='RGR'|
PROCODE='RQ8'|
PROCODE='RVR'|
PROCODE='RDU'|
PROCODE='RNS'|
PROCODE='RFS'|
PROCODE='RX1'|
PROCODE='RXK'|
PROCODE='RBK'|
PROCODE='RWE'|
PROCODE='RDE'|
PROCODE='RLT'|
PROCODE='RCB'|
PROCODE='RC3'|
PROCODE='RD1'|
PROCODE='RR1'|
PROCODE='RCC'|
PROCODE='RJE'|
PROCODE='RTD'|
PROCODE='RPR'|
PROCODE='RL4'|
PROCODE='RXC'|
PROCODE='RD3'|
PROCODE='RFF'|
PROCODE='RVJ'|
PROCODE='RP5'|
PROCODE='RCX'|
PROCODE='RNL'|
PROCODE='RVY'|
PROCODE='RM4'|
PROCODE='RBA'|
PROCODE='RTK'|
PROCODE='RTR'|
PROCODE='RMP'|
PROCODE='RTE'|
PROCODE='RHM'|
PROCODE='RGN'|
PROCODE='RWW'|
PROCODE='RHQ'|
PROCODE='RVL'|
PROCODE='RA7'|
PROCODE='RNA'|
PROCODE='RNZ'|
PROCODE='RAP')SINAPTER
TILE = 2.
EXECUTE.

IF(PROCODE='RJR'|
PROCODE='RFW'|
PROCODE='RV8'|
PROCODE='RXH'|
PROCODE='RCF'|
PROCODE='RKB'|
PROCODE='RFR'|
PROCODE='RGT'|
PROCODE='RF4'|
PROCODE='RGC'|
PROCODE='RRF'|
PROCODE='RWG'|
PROCODE='RHW'|
PROCODE='RW6'|
PROCODE='RVV'|
PROCODE='RD8'|
PROCODE='RTG'|
PROCODE='RN5'|
PROCODE='RJ2'|
PROCODE='RH8'|
PROCODE='REM'|
PROCODE='RQ6'|
PROCODE='RVW'|
PROCODE='RQX'|
PROCODE='RA2'|
PROCODE='RBL'|
PROCODE='RA9'|
PROCODE='RNH'|
PROCODE='RTF'|
PROCODE='RWA'|
PROCODE='RN1'|
PROCODE='RKE'|
PROCODE='RAJ'|
PROCODE='RM3'|
```

```
PROCODE='RJ7'|
PROCODE='RCD'|
PROCODE='RDZ'|
PROCODE='RMC'|
PROCODE='RQM'|
PROCODE='RAL'|
PROCODE='RJZ')SINAPTERTI
LE = 3.
EXECUTE.
```

## 7.2. Codes for NHS Acute Trusts

| Trust Code | Trust Name |
|---|---|
| 5QT | Isle Of Wight |
| RA2 | Royal Surrey County Hospital NHS Trust |
| RA3 | Weston Area Health NHS Trust |
| RA4 | Yeovil District Hospital NHS Foundation Trust |
| RA7 | University Hospitals Of Bristol NHS Foundation Trust |
| RA9 | South Devon Healthcare NHS Foundation Trust |
| RAE | Bradford Teaching Hospitals NHS Foundation Trust |
| RAJ | Southend University Hospital NHS Foundation Trust |
| RAL | Royal Free Hampstead NHS Trust |
| RAP | North Middlesex University Hospital NHS Trust |
| RAS | The Hillingdon Hospital NHS Trust |
| RAX | Kingston Hospital NHS Trust |
| RBA | Taunton And Somerset NHS Foundation Trust |
| RBD | Dorset County Hospital NHS Foundation Trust |
| RBK | Walsall Hospitals NHS Trust |
| RBL | Wirral University Teaching Hospital NHS Foundation Trust |
| RBN | St Helens And Knowsley Hospitals NHS Trust |
| RBT | Mid Cheshire Hospitals NHS Foundation Trust |
| RBZ | Northern Devon Healthcare NHS Trust |
| RC1 | Bedford Hospital NHS Trust |
| RC3 | Ealing Hospital NHS Trust |
| RC9 | Luton And Dunstable Hospital NHS Foundation Trust |
| RCB | York Hospitals NHS Foundation Trust |
| RCC | Scarborough And North East Yorkshire Health Care NHS Trust |
| RCD | Harrogate And District NHS Foundation Trust |
| RCF | Airedale NHS Trust |
| RCX | The Queen Elizabeth Hospital King's Lynn NHS Trust |
| RD1 | Royal United Hospital Bath NHS Trust |
| RD3 | Poole Hospital NHS Foundation Trust |
| RD7 | Heatherwood And Wexham Park Hospitals NHS Foundation Trust |
| RD8 | Milton Keynes Hospital NHS Foundation Trust |
| RDD | Basildon And Thurrock University Hospitals NHS Foundation Trust |
| RDE | Colchester Hospital University NHS Foundation Trust |
| RDU | Frimley Park Hospital NHS Foundation Trust |
| RDZ | The Royal Bournemouth And Christchurch Hospitals NHS Foundation Trust |
| RE9 | South Tyneside NHS Foundation Trust |
| REF | Royal Cornwall Hospitals NHS Trust |

| | |
|---|---|
| REM | Aintree University Hospitals NHS Foundation Trust |
| RF4 | Barking, Havering And Redbridge Hospitals NHS Trust |
| RFF | Barnsley Hospital NHS Foundation Trust |
| RFR | The Rotherham NHS Foundation Trust |
| RFS | Chesterfield Royal Hospital NHS Foundation Trust |
| RFW | West Middlesex University Hospital NHS Trust |
| RG2 | Queen Elizabeth Hospital NHS Trust |
| RG3 | Bromley Hospitals NHS Trust |
| RGC | Whipps Cross University Hospital NHS Trust |
| RGN | Peterborough And Stamford Hospitals NHS Foundation Trust |
| RGP | James Paget University Hospitals NHS Foundation Trust |
| RGQ | Ipswich Hospital NHS Trust |
| RGR | West Suffolk Hospitals NHS Trust |
| RGT | Cambridge University Hospitals NHS Foundation Trust |
| RGZ | Queen Mary's Sidcup NHS Trust |
| RH8 | Royal Devon And Exeter NHS Foundation Trust |
| RHM | Southampton University Hospitals NHS Trust |
| RHQ | Sheffield Teaching Hospitals NHS Foundation Trust |
| RHU | Portsmouth Hospitals NHS Trust |
| RHW | Royal Berkshire NHS Foundation Trust |
| RJ1 | Guy's And St Thomas' NHS Foundation Trust |
| RJ2 | The Lewisham Hospital NHS Trust |
| RJ5 | St Marys |
| RJ6 | Mayday Healthcare NHS Trust |
| RJ7 | St George's Healthcare NHS Trust |
| RJC | South Warwickshire General Hospitals NHS Trust |
| RJD | Mid Staffordshire NHS Foundation Trust |
| RJE | University Hospital Of North Staffordshire NHS Trust |
| RJF | Burton Hospitals NHS Trust |
| RJL | Northern Lincolnshire And Goole Hospitals NHS Foundation Trust |
| RJN | East Cheshire NHS Trust |
| RJR | Countess Of Chester Hospital NHS Foundation Trust |
| RJZ | King's College Hospital NHS Foundation Trust |
| RK5 | Sherwood Forest Hospitals NHS Foundation Trust |
| RK9 | Plymouth Hospitals NHS Trust |
| RKB | University Hospitals Coventry And Warwickshire NHS Trust |
| RKE | The Whittington Hospital NHS Trust |
| RL4 | The Royal Wolverhampton Hospitals NHS Trust |
| RLN | City Hospitals Sunderland NHS Foundation Trust |
| RLQ | Hereford Hospitals NHS Trust |

| | |
|---|---|
| RLT | George Eliot Hospital NHS Trust |
| RM1 | Norfolk And Norwich University Hospitals NHS Foundation Trust |
| RM2 | University Hospital Of South Manchester NHS Foundation Trust |
| RM3 | Salford Royal NHS Foundation Trust |
| RM4 | Trafford Healthcare NHS Trust |
| RMC | Bolton Hospitals NHS Trust |
| RMP | Tameside Hospital NHS Foundation Trust |
| RN1 | Winchester And Eastleigh Healthcare NHS Trust |
| RN3 | Swindon And Marlborough NHS Trust |
| RN5 | Basingstoke And North Hampshire NHS Foundation Trust |
| RN7 | Dartford And Gravesham NHS Trust |
| RNA | Dudley Group Of Hospitals NHS Trust |
| RNH | Newham University Hospital NHS Trust |
| RNJ | Bart's And The London NHS Trust |
| RNL | North Cumbria University Hospitals NHS Trust |
| RNQ | Kettering General Hospital NHS Trust |
| RNS | Northampton General Hospital NHS Trust |
| RNZ | Salisbury NHS Foundation Trust |
| RP5 | Doncaster And Bassetlaw Hospitals NHS Foundation Trust |
| RPA | Medway NHS Foundation Trust |
| RPL | Worthing And Southlands Hospitals NHS Trust |
| RPR | Royal West Sussex NHS Trust |
| RQ6 | Royal Liverpool And Broadgreen University Hospitals NHS Trust |
| RQ8 | Mid Essex Hospital Services NHS Trust |
| RQM | Chelsea And Westminster Hospital NHS Foundation Trust |
| RQN | Hammersmith |
| RQQ | Hinchingbrooke Health Care NHS Trust |
| RQW | The Princess Alexandra Hospital NHS Trust |
| RQX | Homerton University Hospital NHS Foundation Trust |
| RR1 | Heart Of England NHS Foundation Trust |
| RR7 | Gateshead Health NHS Foundation Trust |
| RR8 | Leeds Teaching Hospitals NHS Trust |
| RRF | Wrightington, Wigan And Leigh NHS Trust |
| RRK | University Hospital Birmingham NHS Foundation Trust |
| RRV | University College London Hospitals NHS Foundation Trust |
| RTD | The Newcastle Upon Tyne Hospitals NHS Foundation Trust |
| RTE | Gloucestershire Hospitals NHS Foundation Trust |
| RTF | Northumbria Healthcare NHS Foundation Trust |
| RTG | Derby Hospitals NHS Foundation Trust |
| RTH | Oxford Radcliffe Hospitals NHS Trust |

| | |
|---|---|
| RTK | Ashford And St Peter's Hospitals NHS Trust |
| RTP | Surrey And Sussex Healthcare NHS Trust |
| RTR | South Tees Hospitals NHS Trust |
| RTX | University Hospitals Of Morecambe Bay NHS Trust |
| RV8 | North West London Hospitals NHS Trust |
| RVJ | North Bristol NHS Trust |
| RVL | Barnet And Chase Farm Hospitals NHS Trust |
| RVR | Epsom And St Helier University Hospitals NHS Trust |
| RVV | East Kent Hospitals University NHS Trust |
| RVW | North Tees And Hartlepool NHS Foundation Trust |
| RVY | Southport And Ormskirk Hospital NHS Trust |
| RW3 | Central Manchester And Manchester Children's University Hospitals NHS Trust |
| RW6 | Pennine Acute Hospitals NHS Trust |
| RWA | Hull And East Yorkshire Hospitals NHS Trust |
| RWD | United Lincolnshire Hospitals NHS Trust |
| RWE | University Hospitals Of Leicester NHS Trust |
| RWF | Maidstone And Tunbridge Wells NHS Trust |
| RWG | West Hertfordshire Hospitals NHS Trust |
| RWH | East And North Hertfordshire NHS Trust |
| RWJ | Stockport NHS Foundation Trust |
| RWP | Worcestershire Acute Hospitals NHS Trust |
| RWW | North Cheshire Hospitals NHS Trust |
| RWY | Calderdale And Huddersfield NHS Foundation Trust |
| RX1 | Nottingham University Hospitals NHS Trust |
| RXC | East Sussex Hospitals NHS Trust |
| RXF | Mid Yorkshire Hospitals NHS Trust |
| RXH | Brighton And Sussex University Hospitals NHS Trust |
| RXK | Sandwell And West Birmingham Hospitals NHS Trust |
| RXL | Blackpool, Fylde And Wyre Hospitals NHS Foundation Trust |
| RXN | Lancashire Teaching Hospitals NHS Foundation Trust |
| RXP | County Durham And Darlington NHS Foundation Trust |
| RXQ | Buckinghamshire Hospitals NHS Trust |
| RXR | East Lancashire Hospitals NHS Trust |
| RXW | Shrewsbury And Telford Hospital NHS Trust |

## 7.3. Comorbidity codes

| ICD Code | Decode diagnosis |
|---|---|
| **C000** | Malignant neoplasm of external upper lip |
| **C001** | Malignant neoplasm of external lower lip |
| **C002** | Malignant neoplasm of external lip, unspecified |
| **C003** | Malignant neoplasm of upper lip, inner aspect |
| **C004** | Malignant neoplasm of lower lip, inner aspect |
| **C005** | Malignant neoplasm of lip, unspecified, inner aspect |
| **C006** | Malignant neoplasm of commissure of lip |
| **C008** | Malignant neoplasm of overlapping lesion of lip |
| **C009** | Malignant neoplasm of lip, unspecified |
| **C01X** | Malignant neoplasm of base of tongue |
| **C020** | Malignant neoplasm of dorsal surface tongue |
| **C021** | Malignant neoplasm of border of tongue |
| **C022** | Malignant neoplasm of ventral surface of tongue |
| **C023** | Malignant neo of anterior two-thirds of tongue, part unspecified |
| **C024** | Malignant neoplasm of lingual tonsil |
| **C028** | Malignant neoplasm of overlapping lesion of tongue |
| **C029** | Malignant neoplasm of tongue, unspecified |
| **C030** | Malignant neoplasm of upper gum |
| **C031** | Malignant neoplasm of lower gum |
| **C039** | Malignant neoplasm of gum unspecified |
| **C040** | Malignant neoplasm of floor of anterior floor of mouth |
| **C041** | Malignant neoplasm of lateral floor of mouth |
| **C048** | Malignant neoplasm, overlapping lesion of floor of mouth |
| **C049** | Malignant neoplasm of floor of mouth, floor of mouth, unspecified |
| **C050** | Malignant neoplasm of hard palate |
| **C051** | Malignant neoplasm of soft palate |
| **C052** | Malignant neoplasm of uvula |
| **C058** | Malignant neoplasm, overlapping lesion of palate |
| **C059** | Malignant neoplasm of palate, unspecified |
| **C060** | Malignant neoplasm cheek mucosa |
| **C061** | Malignant neoplasm of vestibule of mouth |
| **C062** | Malignant neoplasm of retromolar area |
| **C068** | Malignant neoplasm, overlap les of oth & unsp part of mouth |
| **C069** | Malignant neoplasm of part of mouth, unspecified |
| **C07X** | Malignant neoplasm of parotid gland |
| **C080** | Malignant neoplasm of submandibular gland |
| **C081** | Malignant neoplasm of sublingual gland |
| **C088** | Malignant neoplasm, overlapping lesion of major saliv gland |
| **C089** | Malignant neoplasm of major salivary gland, unspecified |
| **C090** | Malignant neoplasm tonsillar fossa |
| **C091** | Malig neo of tonsillar pillar (anterior)(posterior) |

| | |
|---|---|
| **C098** | Malignant neoplasm of overlapping lesion of tonsil |
| **C099** | Malignant neoplasm of tonsil unspecified |
| **C100** | Malignant neoplasm of vallecula |
| **C101** | Malignant neoplasm of anterior surface of epiglottis |
| **C102** | Malignant neoplasm of lateral wall of oropharynx |
| **C103** | Malignant neoplasm of posterior wall of oropharynx |
| **C104** | Malignant neoplasm of branchial cleft |
| **C108** | Malignant neoplasm overlapping lesion of oropharynx |
| **C109** | Malignant neoplasm of oropharynx unspecified |
| **C110** | Malignant neoplasm of superior wall of nasopharynx |
| **C111** | Malignant neoplasm of posterior wall of nasopharynx |
| **C112** | Malignant neoplasm of lateral wall of nasopharynx |
| **C113** | Malignant neoplasm of anterior wall of nasopharynx |
| **C118** | Malignant neoplasm overlapping lesion of nasopharynx |
| **C119** | Malignant neoplasm of nasopharynx unspecified |
| **C12X** | Malignant neoplasm of pyriform sinus |
| **C130** | Malignant neoplasm of hypopharynx, postcricoid region |
| **C131** | Malig neoplasm aryepiglottic fold, hypopharyngeal aspect |
| **C132** | Malignant neoplasm posterior wall of hypopharynx |
| **C138** | Malignant neoplasm overlapping lesion of hypopharynx |
| **C139** | Malignant neoplasm of hypopharynx unspecified |
| **C140** | Malignant neoplasm of pharynx, unsp |
| **C142** | Malignant neoplasm of Waldeyer's ring |
| **C148** | Malig neo, overlapping lesion of lip, oral cavity & pharynx |
| **C150** | Malignant neoplasm of cervical part of oesophagus |
| **C151** | Malignant neoplasm of thoracic part of oesophagus |
| **C152** | Malignant neo of abdominal part of oesophagus |
| **C153** | Malignant neoplasm of upper third of oesophagus |
| **C154** | Malignant neoplasm of middle third of oesophagus |
| **C155** | Malignant neoplasm of lower third of oesophagus |
| **C158** | Malignant neoplasm overlapping lesion of oesophagus |
| **C159** | Malignant neoplasm of oesophagus unspecified |
| **C160** | Malignant neoplasm of cardia of stomach |
| **C161** | Malignant neoplasm of fundus of stomach |
| **C162** | Malignant neoplasm of body of stomach |
| **C163** | Malignant neoplasm of pyloric antrum |
| **C164** | Malignant neoplasm of pylorus |
| **C165** | Malignant neoplasm of lesser curvature of stomach, unsp |
| **C166** | Malignant neoplasm of greater curvature of stomach, unsp |
| **C168** | Malignant neoplasm overlapping lesion of stomach |
| **C169** | Malignant neoplasm of stomach, unspecified |
| **C170** | Malignant neoplasm of small intestine, duodenum |
| **C171** | Malignant neoplasm of small intestine, jejunum |

| | |
|---|---|
| **C172** | Malignant neoplasm of small intestine, ileum |
| **C173** | Malignant neoplasm of small intestine, Meckel's diverticulum |
| **C178** | Malignant neoplasm overlapping lesion of small intestine |
| **C179** | Malignant neoplasm of small intestine, unspecified |
| **C180** | Malignant neoplasm of caecum |
| **C181** | Malignant neoplasm of appendix |
| **C182** | Malignant neoplasm of ascending colon |
| **C183** | Malignant neoplasm of hepatic flexure |
| **C184** | Malignant neoplasm of transverse colon |
| **C185** | Malignant neoplasm of splenic flexure |
| **C186** | Malignant neoplasm of descending colon |
| **C187** | Malignant neoplasm of sigmoid colon |
| **C188** | Malignant neoplasm overlapping lesion of colon |
| **C189** | Malignant neoplasm of colon, unspecified |
| **C19X** | Malignant neoplasm of rectosigmoid junction |
| **C20X** | Malignant neoplasm of rectum |
| **C210** | Malignant neoplasm of anus, unspecified |
| **C211** | Malignant neoplasm of anal canal |
| **C212** | Malignant neoplasm of cloacogenic zone |
| **C218** | Malig neo, overlapping lesion of rectum, anus and anal canal |
| **C220** | Malignant neoplasm, liver cell carcinoma |
| **C221** | Malignant neoplasm, intrahep bile duct carcinoma |
| **C222** | Malignant neoplasm, hepatoblastoma |
| **C223** | Malignant neoplasm, angiosarcoma of liver |
| **C224** | Malignant neoplasm, other sarcomas of liver |
| **C227** | Malignant neoplasm, oth spec carcinomas of liver |
| **C229** | Malignant neoplasm, liver, unspecified |
| **C23X** | Malignant neoplasm of gallbladder |
| **C240** | Malignant neoplasm of extrahepatic bile duct |
| **C241** | Malignant neoplasm of Ampulla of Vater |
| **C248** | Malignant neoplasm overlapping lesion of biliary tract |
| **C249** | Malignant neoplasm of biliary tract, unspecified |
| **C250** | Malignant neoplasm of head of pancreas |
| **C251** | Malignant neoplasm of body of pancreas |
| **C252** | Malignant neoplasm of tail of pancreas |
| **C253** | Malignant neoplasm of pancreatic duct |
| **C254** | Malignant neoplasm of endocrine pancreas |
| **C257** | Malignant neoplasm of other parts of pancreas |
| **C258** | Malignant neoplasm, overlapping lesion of pancreas |
| **C259** | Malignant neoplasm of pancreas, unspecified |
| **C260** | Malignant neoplasm of intestinal tract, part unsp |
| **C261** | Malignant neoplasm of spleen |
| **C268** | Malignant neoplasm, overlapping lesion of digestive system |

| | |
|---|---|
| **C269** | Malignant neoplasm of ill-def sites within digestive system |
| **C300** | Malignant neoplasm of nasal cavity |
| **C301** | Malignant neoplasm of middle ear |
| **C310** | Malignant neoplasm of maxillary sinus |
| **C311** | Malignant neoplasm of ethmoidal sinus |
| **C312** | Malignant neoplasm of frontal sinus |
| **C313** | Malignant neoplasm of sphenoidal sinus |
| **C318** | Malignant neoplasm, overlapping lesion accessory sinuses |
| **C319** | Malignant neoplasm of accessory sinus, unsp |
| **C320** | Malignant neoplasm of glottis |
| **C321** | Malignant neoplasm of supraglottis |
| **C322** | Malignant neoplasm of subglottis |
| **C323** | Malignant neoplasm of laryngeal cartilage |
| **C328** | Malignant neoplasm, overlapping lesion of larynx |
| **C329** | Malignant neoplasm of larynx, unspecified |
| **C33X** | Malignant neoplasm of trachea |
| **C340** | Malignant neoplasm of main bronchus |
| **C341** | Malignant neoplasm of upper lobe, bronchus or lung |
| **C342** | Malignant neoplasm of middle lobe, bronchus or lung |
| **C343** | Malignant neoplasm of lower lobe, bronchus or lung |
| **C348** | Malignant neoplasm of overlap les of bronchus & lung |
| **C349** | Malignant neoplasm of bronchus or lung, unspec |
| **C37X** | Malignant neoplasm of thymus |
| **C380** | Malignant neoplasm of heart, mediastinum & pleura, heart |
| **C381** | Malignant neoplasm of anterior mediastinum |
| **C382** | Malignant neoplasm of posterior mediastinum |
| **C383** | Malig neo heart, mediastinum & pleura,mediastinum,part unsp |
| **C384** | Malignant neoplasm of pleura |
| **C388** | Malig neo, overlapping lesion of heart, mediastinum & pleur |
| **C390** | Malignant neoplasm of upper respiratory tract, part unsp |
| **C398** | Malignant neoplasm, overlap lesion of resp & intrathor orgs |
| **C399** | Malignant neoplasm of ill-def sites within the resp sys |
| **C400** | Malignant neoplasm of scapula and long bones of upper limb |
| **C401** | Malignant neoplasm of short bones of upper limb |
| **C402** | Malignant neoplasm of long bones of lower limb |
| **C403** | Malignant neoplasm of short bones of lower limb |
| **C408** | Malignant neoplasm, overlap les bone and artic cart of limb |
| **C409** | Malignant neoplasm of bone and artic cart of limb, unsp |
| **C410** | Malignant neoplasm of bones of skull and face |
| **C411** | Malignant neoplasm of mandible |
| **C412** | Malignant neoplasm of vertebral column |
| **C413** | Malignant neoplasm of ribs, sternum and clavicle |
| **C414** | Malignant neoplasm of sacrum and coccyx |

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| **C418** | Malignant neoplasm, overlap lesion bon and articular cart |
| **C419** | Malignant neoplasm of bone and articular cartilage, unsp |
| **C430** | Malignant melanoma of lip |
| **C431** | Malignant melanoma of eyelid, including canthus |
| **C432** | Malignant melanoma of ear and ext auricular canal |
| **C433** | Malignant melanoma of other and unspecified parts of face |
| **C434** | Malignant melanoma of scalp and neck |
| **C435** | Malignant melanoma of trunk |
| **C436** | Malignant melanoma of upper limb, including shoulder |
| **C437** | Malignant melanoma of lower limb, including hip |
| **C438** | Malignant melanoma of skin |
| **C439** | Malignant melanoma of skin, unsp |
| **C450** | Mesothelioma of pleura |
| **C451** | Mesothelioma of peritoneum |
| **C452** | Mesothelioma of pericardium |
| **C457** | Mesothelioma of other sites |
| **C459** | Mesothelioma, unspecified |
| **C460** | Kaposi's sarcoma of skin |
| **C461** | Kaposi's sarcoma of soft tissue |
| **C462** | Kaposi's sarcoma of palate |
| **C463** | Kaposi's sarcoma of lymph nodes |
| **C467** | Kaposi's sarcoma of other sites |
| **C468** | Kaposi's sarcoma of multiple organs |
| **C469** | Kaposi's sarcoma, unspecified |
| **C470** | Malignant neoplasm of peripheral nerve of head, face & neck |
| **C471** | Malignant neoplasm of peripheral nerve, upp limb, incl should |
| **C472** | Malignant neoplasm of peripheral nerve of low limb, incl hi |
| **C473** | Malignant neoplasm of peripheral nerve of thorax |
| **C474** | Malignant neoplasm of peripheral nerve of abdomen |
| **C475** | Malignant neoplasm of peripheral nerve of pelvis |
| **C476** | Malignant neoplasm of peripheral nerve of trunk, unspec |
| **C478** | Malignant neoplasm, overlap lesion periph nerve & auton ns |
| **C479** | Malignant neoplasm periph nerve & autonomic ns, unspec |
| **C480** | Malignant neoplasm of retroperitoneum |
| **C481** | Malignant neoplasm of spec parts of peritoneum |
| **C482** | Malignant neoplasm of peritoneum, unsp |
| **C488** | Malignant neoplasm of overlap lesion retroperit & peritoneu |
| **C490** | Malignant neoplasm of conn and soft tiss head, face & neck |
| **C491** | Malignant neoplasm of conn and soft tiss upp limb,inc shoul |
| **C492** | Malignant neoplasm of conn and soft tiss,lower limb,inc hip |
| **C493** | Malignant neoplasm of conn and soft tiss of thorax |
| **C494** | Malignant neoplasm of conn and soft tiss of abdomen |
| **C495** | Malignant neoplasm of conn and soft tiss of pelvis |

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| **C496** | Malignant neoplasm of conn and soft tiss of trunk, unsp |
| **C498** | Malignant neoplasm, overlap lesion connective & soft tiss |
| **C499** | Malignant neoplasm of connective and soft tissue, unsp |
| **C500** | Malignant neoplasm of nipple and areola |
| **C501** | Malignant neoplasm of central portion of breast |
| **C502** | Malignant neoplasm of upper-inner quadrant of breast |
| **C503** | Malignant neoplasm of lower-inner quadrant of breast |
| **C504** | Malignant neoplasm of upper-outer quadrant of breast |
| **C505** | Malignant neoplasm of lower-outer quadrant of breast |
| **C506** | Malignant neoplasm of axillary tail of breast |
| **C508** | Malignant neoplasm, overlapping lesion of breast |
| **C509** | Malignant neoplasm of breast, unspecified |
| **C510** | Malignant neoplasm of labium majus |
| **C511** | Malignant neoplasm of labium minus |
| **C512** | Malignant neoplasm of clitoris |
| **C518** | Malignant neoplasm of overlapping lesion of vulva |
| **C519** | Malignant neoplasm of vulva, unspecified |
| **C52X** | Malignant neoplasm of vagina |
| **C530** | Malignant neoplasm of endocervix |
| **C531** | Malignant neoplasm of exocervix |
| **C538** | Malignant neoplasm, overlapping lesion of cervix uteri |
| **C539** | Malignant neoplasm of cervix uteri, unsp |
| **C540** | Malignant neoplasm of isthmus uteri |
| **C541** | Malignant neoplasm of endometrium |
| **C542** | Malignant neoplasm of myometrium |
| **C543** | Malignant neoplasm of fundus uteri |
| **C548** | Malignant neoplasm overlapping lesion of corpus uteri |
| **C549** | Malignant neoplasm of corpus uteri, unsp |
| **C55X** | Malignant neoplasm of uterus, part unspecified |
| **C56X** | Malignant neoplasm of ovary |
| **C570** | Malignant neoplasm of fallopian tube |
| **C571** | Malignant neoplasm of broad ligament |
| **C572** | Malignant neoplasm of round ligament |
| **C573** | Malignant neoplasm of parametrium |
| **C574** | Malignant neoplasm of uterine adenexa, unsp |
| **C577** | Malignant neoplasm of other specified female genital organs |
| **C578** | Malignant neoplasm, overlapping lesion female genital organ |
| **C579** | Malignant neoplasm of female genital organ, unspecified |
| **C58X** | Malignant neoplasm of placenta |
| **C600** | Malignant neoplasm of prepuce |
| **C601** | Malignant neoplasm of glans penis |
| **C602** | Malignant neoplasm of body of penis |
| **C608** | Malignant neoplasm, overlapping lesion of penis |

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| **C609** | Malignant neoplasm of penis, unspecified |
| **C61X** | Malignant neoplasm of prostate |
| **C620** | Malignant neoplasm of undescended testis |
| **C621** | Malignant neoplasm of descended testis |
| **C629** | Malignant neoplasm of testis, unspecified |
| **C630** | Malignant neoplasm of epididymis |
| **C631** | Malignant neoplasm of spermatic cord |
| **C632** | Malignant neoplasm of scrotum |
| **C637** | Malignant neoplasm of other specified male genital orgs |
| **C638** | Malignant neoplasm, overlapping lesion male genital orgs |
| **C639** | Malignant neoplasm of male genital organ, unspecified |
| **C64X** | Malignant neoplasm of kidney, except renal pelvis |
| **C65X** | Malignant neoplasm of renal pelvis |
| **C66X** | Malignant neoplasm of ureter |
| **C670** | Malignant neoplasm of trigone of bladder |
| **C671** | Malignant neoplasm of dome of bladder |
| **C672** | Malignant neoplasm of lateral wall of bladder |
| **C673** | Malignant neoplasm of anterior wall of bladder |
| **C674** | Malignant neoplasm of posterior wall of bladder |
| **C675** | Malignant neoplasm of bladder neck |
| **C676** | Malignant neoplasm of ureteric orifice |
| **C677** | Malignant neoplasm of urachus |
| **C678** | Malignant neoplasm, overlapping lesion of bladder |
| **C679** | Malignant neoplasm of bladder, unspecified |
| **C680** | Malignant neoplasm of urethra |
| **C681** | Malignant neoplasm of paraurethral gland |
| **C688** | Malignant neoplasm of overlapping lesion urinary organs |
| **C689** | Malignant neoplasm of urinary organ, unspecified |
| **C690** | Malignant neoplasm of conjunctiva |
| **C691** | Malignant neoplasm of cornea |
| **C692** | Malignant neoplasm of retina |
| **C693** | Malignant neoplasm of choroid |
| **C694** | Malignant neoplasm of ciliary body |
| **C695** | Malignant neoplasm of lacrimal gland and duct |
| **C696** | Malignant neoplasm of orbit |
| **C698** | Malignant neoplasm, overlapping lesion eye and adnexa |
| **C699** | Malignant neoplasm of eye, unspecified |
| **C700** | Malignant neoplasm of, cerebral meninges |
| **C701** | Malignant neoplasm of spinal meninges |
| **C709** | Malignant neoplasm of meninges, unspecified |
| **C710** | Malignant neoplasm of cerebrum, except lobes & ventricles |
| **C711** | Malignant neoplasm of cerebrum, frontal lobe |
| **C712** | Malignant neoplasm of cerebrum, temporal lobe |

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| **C713** | Malignant neoplasm of cerebrum, parietal lobe |
| **C714** | Malignant neoplasm of cerebrum, occipital lobe |
| **C715** | Malignant neoplasm of cerebrum, cerebral ventricle |
| **C716** | Malignant neoplasm of cerebrum, cerebellum |
| **C717** | Malignant neoplasm of cerebrum, brain stem |
| **C718** | Malignant neoplasm of cerebrum, overlapping lesion of brain |
| **C719** | Malignant neoplasm of cerebrum, brain, unspecified |
| **C720** | Malignant neoplasm of spinal cord |
| **C721** | Malignant neoplasm of cauda equina |
| **C722** | Malignant neoplasm of Olfactory nerve |
| **C723** | Malignant neoplasm of Optic nerve |
| **C724** | Malignant neoplasm of Acoustic nerve |
| **C725** | Malignant neoplasm of other and unspecified cranial nerves |
| **C728** | Malignant neoplasm, overlapping lesion brain & other part CNS |
| **C729** | Malignant neoplasm of Central Nervous System, unspecified |
| **C73X** | Malignant neoplasm of thyroid gland |
| **C740** | Malignant neoplasm of cortex of adrenal gland |
| **C741** | Malignant neoplasm of medulla of adrenal gland |
| **C749** | Malignant neoplasm of adrenal gland, unsp |
| **C750** | Malignant neoplasm of parathyroid gland |
| **C751** | Malignant neoplasm of pituitary gland |
| **C752** | Malignant neoplasm of craniopharyngeal duct |
| **C753** | Malignant neoplasm of pineal gland |
| **C754** | Malignant neoplasm of carotid body |
| **C755** | Malignant neoplasm of aortic body and other paraganglia |
| **C758** | Malignant neoplasm, pluriglandular involvement, unspecified |
| **C759** | Malignant neoplasm of endocrine gland, unspecified |
| **C760** | Malignant neoplasm of head, face & neck |
| **C761** | Malignant neoplasm of thorax |
| **C762** | Malignant neoplasm of abdomen |
| **C763** | Malignant neoplasm of pelvis |
| **C764** | Malignant neoplasm of upper limb |
| **C765** | Malignant neoplasm of lower limb |
| **C767** | Malignant neoplasm of other ill-defined sites |
| **C768** | Malignant neoplasm, overlap lesion oth & ill-defined sites |
| **C770** | Sec & uns malig neoplasm of lymph nodes of head, face & nec |
| **C771** | Sec & uns malignant neoplasm of intrathoracic lymph nodes |
| **C772** | Sec & uns malignant neoplasm of intra-abdominal lymph nodes |
| **C773** | Sec & uns malig neoplasm of axillary & upp limb lymph nodes |
| **C774** | Sec & uns malig neoplasm of inguinal & low limb lymph nodes |
| **C775** | Sec & uns malignant neoplasm of intrapelvic lymph nodes |
| **C778** | Sec & uns malig neoplasm of lymph nodes of multiple regions |
| **C779** | Sec & uns malignant neoplasm of lymph node, unspecified |

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| **C780** | Secondary malignant neoplasm of lung |
| **C781** | Secondary malignant neoplasm of mediastinum |
| **C782** | Secondary malignant neoplasm of pleura |
| **C783** | Secondary malignant neoplasm of oth & unsp respiratory orgs |
| **C784** | Secondary malignant neoplasm of small intestine |
| **C785** | Secondary malignant neoplasm of large intest & rectum |
| **C786** | Secondary malignant neoplasm of retroperitoneum & peritoneu |
| **C787** | Secondary malignant neoplasm of liver |
| **C788** | Secondary malignant neoplasm of other & unsp digestive orgs |
| **C790** | Secondary malignant neoplasm of kidney & renal pelvis |
| **C791** | Secondary malignant neoplasm of oth & uns urinary organs |
| **C792** | Secondary malignant neoplasm of skin |
| **C793** | Secondary malignant neoplasm of brain & cerebral meninges |
| **C794** | Secondary malignant neoplasm of oth & unsp parts nervous sy |
| **C795** | Secondary malignant neoplasm of bone and bone marrow |
| **C796** | Secondary malignant neoplasm of ovary |
| **C797** | Secondary malignant neoplasm of adrenal gland |
| **C798** | Secondary malignant neoplasm of other specified sites |
| **C80X** | Malignant neoplasm without specification of site |
| **C810** | Hodgkin's disease, lymphocytic predominance |
| **C811** | Hodgkin's disease, nodular sclerosis |
| **C812** | Hodgkin's disease, mixed cellularity |
| **C813** | Hodgkin's disease, lymphocytic depletion |
| **C817** | Hodgkin's disease, other Hodgkin's disease |
| **C819** | Hodgkin's disease, Hodgkin's disease, unspecified |
| **C820** | Follicular non-Hodgkin's small cleaved cell lymphoma |
| **C821** | Follicular non-Hodg mixed sml cleavd & lge cell lymphoma |
| **C822** | Follicular non-Hodgkin's large cell lymphoma |
| **C827** | Follicular non-Hodgkin's other types of lymphoma |
| **C829** | Follicular non-Hodgkin's unspecified lymphoma |
| **C830** | Diffuse non-Hodgkin's small cell (diffuse)lymphoma |
| **C831** | Diffuse non-Hodgkin's small cleaved cell (diffuse) lymphoma |
| **C832** | Diffuse non-Hodgkin mixed sml & lge cell (diffuse) lymphoma |
| **C833** | Diffuse non-Hodgkin's large cell (diffuse) lymphoma |
| **C834** | Diffuse non-Hodgkin's immunoblastic (diffuse) lymphoma |
| **C835** | Diffuse non-Hodgkin's lymphoblastic (diffuse) lymphoma |
| **C836** | Diffuse non-Hodgkin's lymphoma undifferentiated (diffuse) |
| **C837** | Diffuse non-Hodgkin's lymphoma, Burkitt's tumour |
| **C838** | Other types of diffuse non-Hodgkin's lymphoma |
| **C839** | Diffuse non-Hodgkin's lymphoma, unspecified |
| **C840** | Peripheral and cutaneous T-cell lymphomas, mycosis fungoides |
| **C841** | Peripheral and cutaneous T-cell lymphomas, Sezary's disease |
| **C842** | Peripheral and cutaneous T-cell lymphomas, T-zone lymphoma |

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| **C843** | Periph & cutan T-cell lymphomas, lymphoepithelioid lymphoma |
| **C844** | Periph & cutan T-cell lymphomas, peripheral T-cell lymphoma |
| **C845** | Periph & cutan T-cell lymphomas, oth & unsp T-cell lymphoma |
| **C850** | Oth & unspec types of non-Hodgkin's lymphoma, lymphosarcoma |
| **C851** | Oth & unsp types non-Hodgkin's B-cell lymphoma, unsp |
| **C857** | Oth specified types of non-Hodgkin's lymphoma |
| **C859** | Non-Hodgkin's lymphoma, unspecified type |
| **C883** | Malignant immunoproliferative small intestinal disease |
| **C887** | Other malignant immunoproliferative diseases |
| **C889** | Malignant immunoproliferative disease, unspecified |
| **C900** | Multiple myeloma |
| **C901** | Plasma cell leukaemia |
| **C902** | Malignant plasma cell neoplasm, extramedullary plasmacytoma |
| **C910** | Acute lymphoblastic leukaemia |
| **C911** | Chronic lymphocytic leukaemia |
| **C912** | Subacute lymphocytic leukaemia |
| **C913** | Prolymphocytic leukaemia |
| **C914** | Hairy-cell leukaemia |
| **C915** | Adult T-cell leukaemia |
| **C917** | Other lymphoid leukaemia |
| **C919** | Lymphoid leukaemia, unspecified |
| **C920** | Acute myeloid leukaemia |
| **C921** | Chronic myeloid leukaemia |
| **C922** | Subacute myeloid leukaemia |
| **C923** | Myeloid sarcoma |
| **C924** | Acute promyelocytic leukaemia |
| **C925** | Acute myelomonocytic leukaemia |
| **C927** | Other myeloid leukaemia |
| **C929** | Myeloid leukaemia, unspecified |
| **C930** | Acute monocytic leukaemia |
| **C931** | Chronic monocytic leukaemia |
| **C932** | Subacute monocytic leukaemia |
| **C937** | Other monocytic leukaemia |
| **C939** | Monocytic leukaemia, unspecified |
| **C940** | Acute erythraemia & erythroleukaemia |
| **C941** | Chronic erythraemia |
| **C942** | Acute megakaryoblastic leukaemia |
| **C943** | Mast cell leukaemia |
| **C947** | Other specified leukaemias |
| **C950** | Acute leukaemia of unsp cell type |
| **C951** | Chronic leukaemia unsp cell type |
| **C952** | Subacute leukaemia unsp cell type |
| **C957** | Other leukaemia unspecified cell type |

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| **C959** | Leukaemia, unspecified |
| **C960** | Letterer-Siwe disease |
| **C961** | Malignant histiocytosis |
| **C962** | Malignant mast cell tumour |
| **C963** | True histiocyt lymphoma |
| **C967** | Oth spec malig neop lymphoid h'poietic & related tissue |
| **C969** | Malig neop lymphoid haematopoietic and related tissue unspe |
| **C97X** | Malignant neoplasms of independent (primary) multiple sites |
| **I210** | Acute transmural myocardial infarction of anterior wall |
| **I211** | Acute transmural myocardial infarction of inferior wall |
| **I212** | Acute transmural myocardial infarction of other sites |
| **I213** | Acute transmural myocardial infarction of unspecified site |
| **I214** | Acute subendocardial myocardial infarction |
| **I219** | Acute myocardial infarction, unspecified |
| **I220** | Subsequent myocardial infarction of anterior wall |
| **I221** | Subsequent myocardial infarction of inferior wall |
| **I228** | Subsequent myocardial infarction of other sites |
| **I229** | Subsequent myocardial infarction of unspecified site |
| **I252** | Old myocardial infarction |
| **I500** | Congestive heart failure |
| **I710** | Dissection of aorta [any part] |
| **I711** | Thoracic aortic aneurysm, ruptured |
| **I712** | Thoracic aortic aneurysm, without mention of rupture |
| **I713** | Abdominal aortic aneurysm, ruptured |
| **I714** | Abdominal aortic aneurysm, without mention of rupture |
| **I715** | Thoracoabdominal aortic aneurysm, ruptured |
| **I716** | Thoracoabdominal aortic aneurysm, without mention of ruptur |
| **I718** | Aortic aneurysm of unspecified site, ruptured |
| **I719** | Aortic aneurysm of unspec site, without mention of rupture |
| **I738** | Other specified peripheral vascular diseases |
| **I739** | Peripheral vascular disease, unspecified |
| **I600** | Subarachnoid haemorrhage from carotid siphon and bifurcatio |
| **I601** | Subarachnoid haemorrhage from middle cerebral artery |
| **I602** | Subarachnoid haemorrhage from anterior communicating artery |
| **I603** | Subarachnoid haemorrhage from posterior communicating arter |
| **I604** | Subarachnoid haemorrhage from basilar artery |
| **I605** | Subarachnoid haemorrhage from vertebral artery |
| **I606** | Subarachnoid haemorrhage from other intracranial arteries |
| **I607** | Subarachnoid haemorrhage from intracranial artery, unspec |
| **I608** | Other subarachnoid haemorrhage |
| **I609** | Subarachnoid haemorrhage, unspecified |
| **I610** | Intracerebral haemorrhage in hemisphere, subcortical |
| **I611** | Intracerebral haemorrhage in hemisphere, cortical |

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| **I612** | Intracerebral haemorrhage in hemisphere, unspecified |
| **I613** | Intracerebral haemorrhage in brain stem |
| **I614** | Intracerebral haemorrhage in cerebellum |
| **I615** | Intracerebral haemorrhage, intraventricular |
| **I616** | Intracerebral haemorrhage, multiple localized |
| **I618** | Other intracerebral haemorrhage |
| **I619** | Intracerebral haemorrhage, unspecified |
| **I620** | Subdural haemorrhage (acute)(nontraumatic) |
| **I621** | Nontraumatic extradural haemorrhage |
| **I629** | Intracranial haemorrhage (nontraumatic), unspecified |
| **I630** | Cerebral infarct due to thrombosis of precerebral arteries |
| **I631** | Cerebral infarction due to embolism of precerebral arteries |
| **I632** | Cereb infarct due unsp occlusion or stenos precerebrl arts |
| **I633** | Cerebral infarction due to thrombosis of cerebral arteries |
| **I634** | Cerebral infarction due to embolism of cerebral arteries |
| **I635** | Cerebrl infarct due unspec occlusion or stenos cerebrl arts |
| **I636** | Cereb infarct due cerebral venous thrombosis, nonpyogenic |
| **I638** | Other cerebral infarction |
| **I639** | Cerebral infarction, unspecified |
| **I64X** | Stroke, not specified as haemorrhage or infarction |
| **I650** | Occlusion and stenosis of vertebral artery |
| **I651** | Occlusion and stenosis of basilar artery |
| **I652** | Occlusion and stenosis of carotid artery |
| **I653** | Occlusion and stenosis of multip and bilat precerebrl arts |
| **I658** | Occlusion and stenosis of other precerebral artery |
| **I659** | Occlusion and stenosis of unspecified precerebral artery |
| **I660** | Occlusion and stenosis of middle cerebral artery |
| **I661** | Occlusion and stenosis of anterior cerebral artery |
| **I662** | Occlusion and stenosis of posterior cerebral artery |
| **I663** | Occlusion and stenosis of cerebellar arteries |
| **I664** | Occlusion and stenosis of multiple and bilat cerebrl arts |
| **I668** | Occlusion and stenosis of other cerebral artery |
| **I669** | Occlusion and stenosis of unspecified cerebral artery |
| **I670** | Dissection of cerebral arteries, nonruptured |
| **I671** | Cerebral aneurysm, nonruptured |
| **I672** | Cerebral atherosclerosis |
| **I673** | Progressive vascular leukoencephalopathy |
| **I674** | Hypertensive encephalopathy |
| **I675** | Moyamoya disease |
| **I676** | Nonpyogenic thrombosis of intracranial venous system |
| **I677** | Cerebral arteritis, not elsewhere classified |
| **I678** | Other specified cerebrovascular diseases |
| **I679** | Cerebrovascular disease, unspecified |

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| **I680** | Cerebral amyloid angiopathy |
| **I681** | Cerebral arteritis in infect & parasit dis classif elsewh |
| **I682** | Cerebral arteritis in other diseases classified elsewhere |
| **I688** | Other cerebrovascular disorders in diseases EC |
| **I690** | Sequelae of subarachnoid haemorrhage |
| **I691** | Sequelae of intracerebral haemorrhage |
| **I692** | Sequelae of other nontraumatic intracranial haemorrhage |
| **I693** | Sequelae of cerebral infarction |
| **I694** | Sequelae of stroke, not spec as haemorrhage or infarction |
| **I698** | Sequelae of other and unspecified cerebrovascular diseases |
| **F000** | Dementia in Alzheimer's disease with early onset |
| **F001** | Dementia in Alzheimer's disease with late onset |
| **F002** | Dementia in Alzheimer's disease, atypical or mixed type |
| **F009** | Dementia in Alzheimer's disease, unspecified |
| **F010** | Vascular dementia of acute onset |
| **F011** | Multi-infarct dementia |
| **F012** | Subcortical vascular dementia |
| **F013** | Mixed cortical and subcortical vascular dementia |
| **F018** | Other vascular dementia |
| **F019** | Vascular dementia, unspecified |
| **F020** | Dementia in Pick's disease |
| **F021** | Dementia in Creutzfeldt-Jakob disease |
| **F022** | Dementia in Huntington's disease |
| **F023** | Dementia in Parkinson's disease |
| **F024** | Dementia in human immunodef virus [HIV] disease |
| **F028** | Dementia in other specified diseases classified elsewhere |
| **F03X** | Unspecified dementia |
| **F051** | Delirium superimposed on dementia |
| **J40X** | Bronchitis, not specified as acute or chronic |
| **J410** | Simple chronic bronchitis |
| **J411** | Mucopurulent chronic bronchitis |
| **J418** | Mixed simple and mucopurulent chronic bronchitis |
| **J42X** | Unspecified chronic bronchitis |
| **J430** | MacLeod's syndrome |
| **J431** | Panlobular emphysema |
| **J432** | Centrilobular emphysema |
| **J438** | Other emphysema |
| **J439** | Emphysema, unspecified |
| **J440** | Chronic obstruct pulmonary dis with acute lower resp infec |
| **J441** | Chron obstruct pulmonary dis wth acute exacerbation, unspec |
| **J448** | Other specified chronic obstructive pulmonary disease |
| **J449** | Chronic obstructive pulmonary disease, unspecified |
| **J450** | Predominantly allergic asthma |

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| **J451** | Nonallergic asthma |
| **J458** | Mixed asthma |
| **J459** | Asthma, unspecified |
| **J46X** | Status asthmaticus |
| **J47X** | Bronchiectasis |
| **J60X** | Coal worker’s pneumoconiosis |
| **J61X** | Pneumoconiosis due to asbestos and other mineral fibres |
| **J620** | Pneumoconiosis due to talc dust |
| **J628** | Pneumoconiosis due to other dust containing silica |
| **J630** | Aluminosis (of lung) |
| **J631** | Bauxite fibrosis (of lung) |
| **J632** | Berylliosis |
| **J633** | Graphite fibrosis (of lung) |
| **J634** | Siderosis |
| **J635** | Stannosis |
| **J638** | Pneumoconiosis due to other specified inorganic dusts |
| **J64X** | Unspecified pneumoconiosis |
| **J65X** | Pneumoconiosis associated with tuberculosis |
| **J660** | Byssinosis |
| **J661** | Flax-dresser's disease |
| **J662** | Cannabinosis |
| **J668** | Airway disease due to other specific organic dusts |
| **J670** | Farmer's lung |
| **J671** | Bagassosis |
| **J672** | Bird fancier's lung |
| **J673** | Suberosis |
| **J674** | Maltworker's lung |
| **J675** | Mushroom-worker's lung |
| **J676** | Maple-bark-stripper's lung |
| **J677** | Air-conditioner and humidifier lung |
| **J678** | Hypersensitivity pneumonitis due to other organic dusts |
| **J679** | Hypersensitivity pneumonitis due to unspecified organic dus |
| **M050** | Felty's syndrome |
| **M051** | Rheumatoid lung disease |
| **M052** | Rheumatoid vasculitis |
| **M059** | Seropositive rheumatoid arthritis, unspecified |
| **M060** | Seronegative rheumatoid arthritis |
| **M063** | Rheumatoid nodule |
| **M069** | Rheumatoid arthritis, unspecified |
| **M300** | Polyarteritis nodosa |
| **M301** | Polyarteritis with lung involvement [Churg-Strauss] |
| **M302** | Juvenile polyarteritis |
| **M303** | Mucocutaneous lymph node syndrome [Kawasaki] |

| | |
|---|---|
| **M308** | Other conditions related to polyarteritis nodosa |
| **M310** | Hypersensitivity angiitis |
| **M311** | Thrombotic microangiopathy |
| **M312** | Lethal midline granuloma |
| **M313** | Wegener's granulomatosis |
| **M314** | Aortic arch syndrome [Takayasu] |
| **M315** | Giant cell arteritis with polymyalgia rheumatica |
| **M316** | Other giant cell arteritis |
| **M318** | Other specified necrotizing vasculopathies |
| **M319** | Necrotizing vasculopathy, unspecified |
| **M320** | Drug-induced systemic lupus erythematosus |
| **M321** | Systemic lupus erythematosus with organ or sys involv |
| **M328** | Other forms of systemic lupus erythematosus |
| **M329** | Systemic lupus erythematosus, unspecified |
| **M332** | Polymyositis |
| **M339** | Dermatopolymyositis, unspecified |
| **M340** | Progressive systemic sclerosis |
| **M341** | CR(E)ST syndrome |
| **M342** | Systemic sclerosis induced by drugs and chemicals |
| **M348** | Other forms of systemic sclerosis |
| **M349** | Systemic sclerosis, unspecified |
| **M350** | Sicca syndrome [Sjogren] |
| **M351** | Other overlap syndromes |
| **M352** | Behcet's disease |
| **M353** | Polymyalgia rheumatica |
| **M354** | Diffuse (eosinophilic) fasciitis |
| **M355** | Multifocal fibrosclerosis |
| **M356** | Relapsing panniculitis [Weber-Christian] |
| **M357** | Hypermobility syndrome |
| **K250** | Gastric ulcer, acute with haemorrhage |
| **K251** | Gastric ulcer, acute with perforation |
| **K252** | Gastric ulcer, acute with both haemorrhage and perforation |
| **K253** | Gastric ulcer, acute without haemorrhage or perforation |
| **K254** | Gastric ulcer, chronic or unspecified with haemorrhage |
| **K255** | Gastric ulcer, chronic or unspecified with perforation |
| **K256** | Chronic or unspecified with both haemorrhage and perforatio |
| **K257** | Gastric ulcer, chronic without haemorrhage or perforation |
| **K259** | Unspec as acute or chronic w'out haemorrhage or perforation |
| **K260** | Duodenal ulcer, acute with haemorrhage |
| **K261** | Duodenal ulcer, acute with perforation |
| **K262** | Duodenal ulcer, acute with both haemorrhage and perforation |
| **K263** | Duodenal ulcer, acute without haemorrhage or perforation |
| **K264** | Duodenal ulcer, chronic or unspecified with haemorrhage |

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| **K265** | Duodenal ulcer, chronic or unspecified with perforation |
| **K266** | Chronic or unspecified with both haemorrhage and perforatio |
| **K267** | Duodenal ulcer, chronic without haemorrhage or perforation |
| **K269** | Unspec as acute or chronic w'out haemorrhage or perforation |
| **K270** | Peptic ulcer, acute with haemorrhage |
| **K271** | Peptic ulcer, acute with perforation |
| **K272** | Peptic ulcer, acute with both haemorrhage and perforation |
| **K273** | Peptic ulcer, acute without haemorrhage or perforation |
| **K274** | Peptic ulcer, chronic or unspecified with haemorrhage |
| **K275** | Peptic ulcer, chronic or unspecified with perforation |
| **K276** | Chronic or unspecified with both haemorrhage and perforatio |
| **K277** | Peptic ulcer, chronic without haemorrhage or perforation |
| **K279** | Unspec as acute or chronic w'out haemorrhage or perforation |
| **K280** | Gastrojejunal ulcer, acute with haemorrhage |
| **K281** | Gastrojejunal ulcer, acute with perforation |
| **K282** | Acute with both haemorrhage and perforation |
| **K283** | Acute without haemorrhage or perforation |
| **K284** | Gastrojejunal ulcer, chronic or unspecified with haemorrhag |
| **K285** | Gastrojejunal ulcer, chronic or unspecified with perforatio |
| **K286** | Chronic or unspecified with both haemorrhage and perforatio |
| **K287** | Chronic without haemorrhage or perforation |
| **K289** | Unspec as acute or chronic w'out haemorrhage or perforation |
| **K701** | Alcoholic hepatitis |
| **K702** | Alcoholic fibrosis and sclerosis of liver |
| **K703** | Alcoholic cirrhosis of liver |
| **K704** | Alcoholic hepatic failure |
| **K709** | Alcoholic liver disease, unspecified |
| **K710** | Toxic liver disease with cholestasis |
| **K711** | Toxic liver disease with hepatic necrosis |
| **K712** | Toxic liver disease with acute hepatitis |
| **K713** | Toxic liver disease with chronic persistent hepatitis |
| **K714** | Toxic liver disease with chronic lobular hepatitis |
| **K715** | Toxic liver disease with chronic active hepatitis |
| **K716** | Toxic liver disease with hepatitis, not elsewhere classifie |
| **K717** | Toxic liver disease with fibrosis and cirrhosis of liver |
| **K718** | Toxic liver disease with other disorders of liver |
| **K719** | Toxic liver disease, unspecified |
| **K721** | Chronic hepatic failure |
| **K729** | Hepatic failure, unspecified |
| **K730** | Chronic persistent hepatitis, not elsewhere classified |
| **K731** | Chronic lobular hepatitis, not elsewhere classified |
| **K732** | Chronic active hepatitis, not elsewhere classified |
| **K738** | Other chronic hepatitis, not elsewhere classified |

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| **K739** | Chronic hepatitis, unspecified |
| **K740** | Hepatic fibrosis |
| **K741** | Hepatic sclerosis |
| **K742** | Hepatic fibrosis with hepatic sclerosis |
| **K743** | Primary biliary cirrhosis |
| **K744** | Secondary biliary cirrhosis |
| **K745** | Biliary cirrhosis, unspecified |
| **K746** | Other and unspecified cirrhosis of liver |
| **K753** | Granulomatous hepatitis, not elsewhere classified |
| **K754** | Autoimmune hepatitis |
| **K758** | Other specified inflammatory liver diseases |
| **K764** | Peliosis hepatis |
| **K765** | Hepatic veno-occlusive disease |
| **K766** | Portal hypertension |
| **K767** | Hepatorenal syndrome |
| **K768** | Other specified diseases of liver |
| **E102** | Insulin-dependent diabetes mellitus with renal complication |
| **E103** | Insulin-dependent diabetes mellitus with ophthalmic comps |
| **E104** | Insulin-dependent diabetes mellitus with neurological comps |
| **E105** | Insulin-dependent diabetes mellitus with periph circ comps |
| **E106** | Insulin-dependent diabetes mellitus with other spec comps |
| **E107** | Insulin-dependent diabetes mellitus with multiple comps |
| **E108** | Insulin-dependent diabetes mellitus with unspec comps |
| **E109** | Insulin-dependent diabetes mellitus without complications |
| **E112** | Non-insulin-dependent diabetes mellitus with renal comps |
| **E113** | Non-insulin-dependent diabetes mellitus with ophthalm comps |
| **E114** | Non-insulin-dependent diabetes mellitus with neuro comps |
| **E115** | Non-insulin-depend diabetes mellitus with periph circ comp |
| **E116** | Non-insulin-depend diabetes mellitus with other spec comp |
| **E117** | Non-insulin-dependent diabetes mellitus with multiple comps |
| **E118** | Non-insulin-dependent diabetes mellitus with unspec comps |
| **E119** | Non-insulin-depend diabetes mellitus without complication |
| **E132** | Other specified diabetes mellitus with renal complications |
| **E133** | Other specified diabetes mellitus with ophthalmic comps |
| **E134** | Other specified diabetes mellitus with neurological comps |
| **E135** | Other specified diabetes mellitus with periph circ comps |
| **E136** | Other specified diabetes mellitus with other spec comps |
| **E137** | Other specified diabetes mellitus with multiple comps |
| **E138** | Other specified diabetes mellitus with unspecified comps |
| **E139** | Other specified diabetes mellitus without complications |
| **E142** | Unspecified diabetes mellitus with renal complications |
| **E143** | Unspecified diabetes mellitus with ophthalmic complications |
| **E144** | Unspecified diabetes mellitus with neurological comps |

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|---|---|
| **E145** | Unspecified diabetes mellitus with periph circulatory comps |
| **E146** | Unspecified diabetes mellitus with other specified comps |
| **E147** | Unspecified diabetes mellitus with multiple complications |
| **E148** | Unspecified diabetes mellitus with unspecified complication |
| **E149** | Unspecified diabetes mellitus without complications |
| **G810** | Flaccid hemiplegia |
| **G811** | Spastic hemiplegia |
| **G819** | Hemiplegia, unspecified |
| **G820** | Flaccid paraplegia |
| **G821** | Spastic paraplegia |
| **G822** | Paraplegia, unspecified |
| **N001** | Focal and segmental glomerular lesions |
| **N002** | Diffuse membranous glomerulonephritis |
| **N003** | Diffuse mesangial proliferative glomerulonephritis |
| **N004** | Diffuse endocapillary proliferative glomerulonephritis |
| **N005** | Diffuse mesangiocapillary glomerulonephritis |
| **N007** | Diffuse concentric glomerulonephritis |
| **N010** | Minor glomerular abnormality |
| **N011** | Focal and segmental glomerular lesions |
| **N012** | Diffuse membranous glomerulonephritis |
| **N013** | Diffuse mesangial proliferative glomerulonephritis |
| **N014** | Diffuse endocapillary proliferative glomerulonephritis |
| **N015** | Diffuse mesangiocapillary glomerulonephritis |
| **N016** | Dense deposit disease |
| **N017** | Diffuse concentric glomerulonephritis |
| **N018** | Rapidly progressive nephritic syndrome, other |
| **N019** | Rapidly progressive nephritic syndrome, unspecified |
| **N020** | Minor glomerular abnormality |
| **N021** | Focal and segmental glomerular lesions |
| **N022** | Diffuse membranous glomerulonephritis |
| **N023** | Diffuse mesangial proliferative glomerulonephritis |
| **N024** | Diffuse endocapillary proliferative glomerulonephritis |
| **N025** | Diffuse mesangiocapillary glomerulonephritis |
| **N026** | Recurrent and persistent haematuria, dense deposit disease |
| **N027** | Diffuse concentric glomerulonephritis |
| **N030** | Chronic nephritic syndrome, minor glomerular abnormality |
| **N031** | Focal and segmental glomerular lesions |
| **N032** | Diffuse membranous glomerulonephritis |
| **N033** | Diffuse mesangial proliferative glomerulonephritis |
| **N034** | Diffuse endocapillary proliferative glomerulonephritis |
| **N035** | Diffuse mesangiocapillary glomerulonephritis |
| **N036** | Chronic nephritic syndrome, dense deposit disease |
| **N037** | Diffuse concentric glomerulonephritis |

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|---|---|
| **N038** | Chronic nephritic syndrome, other |
| **N039** | Chronic nephritic syndrome, unspecified |
| **N040** | Nephrotic syndrome, minor glomerular abnormality |
| **N041** | Nephrotic syndrome, focal and segmental glomerular lesions |
| **N042** | Nephrotic syndrome, diffuse membranous glomerulonephritis |
| **N043** | Diffuse mesangial proliferative glomerulonephritis |
| **N044** | Diffuse endocapillary proliferative glomerulonephritis |
| **N045** | Diffuse mesangiocapillary glomerulonephritis |
| **N046** | Nephrotic syndrome, dense deposit disease |
| **N047** | Nephrotic syndrome, diffuse crescentic glomerulonephritis |
| **N048** | Nephrotic syndrome, other |
| **N049** | Nephrotic syndrome, unspecified |
| **N050** | Unspecified nephritic syndrome, minor glomerular abnormalit |
| **N051** | Focal and segmental glomerular lesions |
| **N052** | Diffuse membranous glomerulonephritis |
| **N053** | Diffuse mesangial proliferative glomerulonephritis |
| **N054** | Diffuse endocapillary proliferative glomerulonephritis |
| **N055** | Diffuse mesangiocapillary glomerulonephritis |
| **N056** | Unspecified nephritic syndrome, dense deposit disease |
| **N057** | Diffuse concentric glomerulonephritis |
| **N071** | Focal and segmental glomerular lesions |
| **N072** | Diffuse membranous glomerulonephritis |
| **N073** | Diffuse mesangial proliferative glomerulonephritis |
| **N074** | Diffuse endocapillary proliferative glomerulonephritis |
| **N075** | Diffuse mesangiocapillary glomerulonephritis |
| **N180** | End-stage renal disease |
| **N188** | Other chronic renal failure |
| **N189** | Chronic renal failure, unspecified |
| **N19X** | Unspecified renal failure |
| **N250** | Renal osteodystrophy |
| **Z992** | Dependence on renal dialysis |
| **B200** | HIV disease resulting in mycobacterial infection |
| **B201** | HIV disease resulting in other bacterial infections |
| **B202** | HIV disease resulting in cytomegaloviral disease |
| **B203** | HIV disease resulting in other viral infections |
| **B204** | HIV disease resulting in candidiasis |
| **B205** | HIV disease resulting in other mycoses |
| **B206** | HIV disease resulting in Pneumocystis carinii pneumonia |
| **B207** | HIV disease resulting in multiple infections |
| **B208** | HIV dis resulting in oth infectious and parasitic dis |
| **B209** | HIV disease resulting in unspec infectious or parasitic dis |
| **B210** | HIV disease resulting in Kaposi's sarcoma |
| **B211** | HIV disease resulting in Burkitt's lymphoma |

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| **B212** | HIV dis resulting oth types of non-Hodgkin's lymphoma |
| **B213** | HIV dis result oth mal neo lymphoid haematopoietic rel tis |
| **B217** | HIV disease resulting in multiple malignant neoplasms |
| **B218** | HIV disease resulting in other malignant neoplasms |
| **B219** | HIV disease resulting in unspecified malignant neoplasm |
| **B220** | HIV disease resulting in encephalopathy |
| **B221** | HIV disease resulting in lymphoid interstitial pneumonitis |
| **B222** | HIV disease resulting in wasting syndrome |
| **B227** | HIV dis resulting in multiple diseases classif elsewhere |
| **B230** | Acute HIV infection syndrome |
| **B231** | HIV dis result (persistent) generalized lymphadenopathy |
| **B232** | HIV dis result haematologic / immunologic abnorm NEC |
| **B238** | HIV disease resulting in other specified conditions |
| **B24X** | Unspecified human immunodeficiency virus [HIV] disease |

## 7.4. Published papers

# Safer sedation practice may not translate into improvements in endoscopic outcomes

Sanchoy Sarkar[a,b], Katherine Bowering[a], Waqar Azim[a] and Keith Bodger[a,b]

***Introduction*** Although the literature surrounding sedation practice and endoscopic outcomes remains sparse and controversial, there have been a number of stringent guidelines issued regarding sedation use in endoscopy.

***Aims*** To assess the impact of changes to enhance safer sedation practice on endoscopic outcomes.

***Methods*** Sedation practice was audited in 7234 consecutive gastrointestinal endoscopic procedures in 2004 and protocols for enhancing safer sedation practice were introduced. These included; introduction of a unit sedation policy, exchange of midazolam 10 mg vials to 5 mg repacked syringes, adverse events recording of midazolam use of greater than 5 mg and reversal agents, more stringent patient monitoring procedures and endoscopists education and feedback. A reaudit of 7071 procedures was performed in 2006. Outcomes audited the included midazolam doses, patient intolerance, 30-day postprocedure mortality, reversal agent use and total adverse events.

***Results*** Sedation doses were reduced substantially after intervention [mean midazolam dose (SD): 4.9 mg (2.5) in 2004 vs. 2.9 mg (1.2) in 2006; $P<0.0001$] with no endoscopist using a mean greater than 5 mg in 2006 compared with 19% in 2004 ($P=0.005$). The use of reversal agents (0.6 vs. 0.7% for 2004 and 2006, respectively; $P=0.74$), mortality (1.0 vs. 1.3%; $P=0.23$) and the adverse events (1.7 vs. 2%; $P=0.44$) were similar. Unsuccessful procedures because of patient intolerance increased from 0.1 to 1.9% ($P<0.0001$).

***Conclusion*** Although protocols to enhance safer sedation practice substantially reduced sedation doses used; this did not, however, translate into improved endoscopic outcomes. Moreover, incomplete procedures because of poor tolerance increased. *Eur J Gastroenterol Hepatol* 21:534–543 © 2009 Wolters Kluwer Health | Lippincott Williams & Wilkins.

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Keywords: adverse events, endoscopic complications, endoscopic outcomes, endoscopy, mortality, National Confidential Enquiry into Post Operative Deaths, sedation

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## Introduction

Sedation is used widely in endoscopy as it can make a potentially unpleasant procedure more acceptable to patients [1–3]. Indeed, a number of studies have shown that sedation not only improves patient satisfaction and willingness to have a repeat endoscopy, but also improves endoscopists' satisfaction with the procedure and the likelihood of procedure completion [1–5]. Despite these obvious advantages, the use of sedation in endoscopy has, however, come under close scrutiny in the UK, particularly after the publication of a report entitled 'scoping our practice' by an independent governmental advisory body called the National Confidential Enquiry into Post Operative Deaths (NCEPOD) in 2004 [6].

NCEPOD audited 1818 deaths within 30 days of an endoscopic procedure for causal factors contributing to mortality. One of the main findings of this national audit was that 14% of patients were judged to have excessive doses of sedation and hence implicated as a contributing factor towards mortality. There were obvious limitations when the focus of scrutiny is solely on cases selected for poor outcome – there was no analysis of the size of the denominator population of control cases who survived despite similar levels of sedation. Nevertheless, the NCEPOD report concluded with firm recommendations regarding desirable improvements in the monitoring of patients during procedures and protocols for drug administration.

A number of specialist advisory bodies including the Royal College of Anaesthesia, the British Society of Gastroenterology (BSG), the National Patient Safety Agency and NCEPOD have produced firm guidance for 'safe sedation practice' including the specification of maximal doses of midazolam use (5 mg) and the need to reduce benzodiazepine doses when used in combination with opiates and in the elderly [2,7–19]. Hence, there has been an emphasis on the reduction of sedation use in endoscopy in the UK over recent years and midazolam

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administration is now a regularly audited quality indicator embedded within the Global Rating Scale (GRS) [20]. This is a national, biannually published scale that is used to measure the safety and quality standards of endoscopy units in the UK. The GRS is important not only for accrediting endoscopy units for service and training, but also as part of the assessment process for unit's eligibility to perform colonoscopy for population bowel cancer screening and its associated financial flows.

This study was interested in answering the following question: what would be the impact on endoscopy outcomes after implementation of the guidance towards 'safe sedation practice'? The hypothesis tested would be that adherence to guidance would improve sedation practice, and thus, should improve endoscopic outcomes. To test this hypothesis, the following audit cycle was undertaken:

(1) Baseline sedation practice was audited.
(2) Changes were implemented to improve sedation practice (intervention).
(3) The effectiveness of these changes on sedation practice was reaudited to ensure improvements were made.
(4) The effectiveness of the changes in sedation practice on endoscopic outcomes was examined by auditing: patient intolerance, the use of reversal agents, total adverse events and 30-day postprocedure mortality (PPM) before and after the intervention.

## Methods

### Setting

This single-center retrospective audit was conducted between June 2004 and December 2006 at University Hospitals Aintree, which is a large teaching hospital performing approximately 14 500 adult gastrointestinal (GI) endoscopies per annum.

### Sedation and selection criteria

The endoscopy unit stocks midazolam as the only benzodiazepine and fentanyl as the only opiate and the sedation is given primarily by the endoscopist. All patients for diagnostic upper GI endoscopy and flexible sigmoidoscopy are offered the option of receiving intravenous sedation (midazolam). Patients undergoing either colonoscopy or therapeutic procedures are routinely given sedation (midazolam ± fentanyl) unless there are contraindications or the patient specifically elects to have no sedation. If a patient requires a procedure that cannot be performed using the standard sedation, then general anesthesia (GA) is used on the unit after special arrangements with an anesthetist.

### Summary of sedation procedures before audit

All patients were assessed for comorbidity and risk factors before their endoscopic procedure and were clinically monitored throughout their course by the endoscopist and the endoscopy nurse. All the sedated patients who had secure intravenous access with a blue or pink venflon before the procedure, were monitored with pulse oximetry; before, during and after the procedure, and received supplementary oxygen during the procedure. The reversal agents, flumazanil and naloxone, were stocked in each theatre and the unit was fully equipped with resuscitation equipment with regular staff updates on its use. If a patient required combination sedation, then the opiate was administered before the benzodiazipine.

### Audit cycle

#### *Audit 2004 (preintervention)*

A benchmark audit of endoscopic practice was performed by collecting data retrospectively over a 6-month period from 1 July to 31 December 2004 on 7234 sequential GI diagnostic and therapeutic endoscopic procedures performed on 5999 patients as identified by the computerized endoscopy database. The information was collected on a standard proforma from the endoscopy database, the hospital informatics IT system and patients' death certificates and entered onto an ACCESS database. In addition to the demographic details of the patient population and the procedures, the sedation doses, and endoscopic outcomes were measured including:

(1) Patient intolerance of a procedure.
(2) Use of sedation reversal agents (i.e. naloxone or flumazenil).
(3) Thirty-day PPM.
(4) Total adverse events.

#### *Intervention: 'procedures to enhance safer sedation practice'*

A number of interventions to improve sedation practice were introduced in line with the recommendations from NCEPOD [6], BSG [16], and the National Endoscopy Team (GRS) [20].

Key components were:

(1) A multidisciplinary team was established to: (i) formulate local guidelines of best sedation practice; (ii) implement changes on the unit regarding sedation practice; (iii) enforce guideline adherence.
(2) A unit sedation policy was introduced.
(3) Ten-milligrams vials of midazolam were removed. A pharmacy department regulated prefilled and prepacked 5 mg dosed syringes of midazolam were introduced.
(4) Adverse event logbooks were introduced in each theater. Criteria recorded as an adverse event included the use of more than 5 mg of midazolam per procedure and the use of reversal agents in any procedure.

(5) The audit results of the 2004 data were presented at the departmental audit meeting and personal results of sedation use was confidentially disseminated to each endoscopist.
(6) Endoscopists were educated about (a) the NCEPOD findings and recommendations, (b) the unit sedation policy and (c) the adverse events log criteria.
(7) Adverse events were audited quarterly and results disseminated (fed-back) to the endoscopists and staff.
(8) All patients (sedated and unsedated) received supplementary oxygen and pulse oximetry throughout their procedure.
(9) All patients had blood pressure recording taken before and after their procedure and select patients (elderly, cardiovascular comorbidity, therapeutic procedures) had ambulatory recordings throughout their procedure.
(10) Ambulatory ECG recording was introduced for select patients (cardiac history, therapeutic procedures).
(11) The monitoring of patient's conscious state and comfort levels; during the procedure, earlier to any additional sedation administration, and after the procedure, was introduced.

***Audit 2006 (postintervention)***

A second 6-month retrospective audit was conducted between 1 March and 30 December 2006 on 7071 consecutive endoscopic procedures on 5946 patients to observe the effectiveness of the interventions on sedation practice and endoscopic outcomes in a similar manner as described for the audit in 2004.

### Definitions

Patient intolerance of a procedure was defined as an endoscopist reporting an unsuccessful procedure in a sedated patient because of intolerance. This is a routinely used option in the compulsory 'complications' screen of the endoscopy-reporting tool. Reversal agents' use was defined as the intravenous administration of either flumazenil or naloxone before, during or after the procedure as record by the endoscopy-reporting tool. Thirty-day PPM was defined as any death that occurred within 30 days of an audited endoscopic procedure.

Immediate complication was defined as; perforation, hypoxia, cardiorespiratory arrest, pathological tachycardia, shock, hemorrhage, aspiration, vasovagal episode, hypotension, intracerebral event, patient injury and death occurring at the time of an endoscopic procedure, or in recovery. Total adverse event was defined as the sum of counts for immediate complications, reversal agent use and PPM.

Therapeutic procedures included therapeutic upper GI endoscopy (dilatation, laser or argon beam therapy, procedures to attain hemostasis of upper GI bleeds, feeding tube insertions, endoprosthesis insertion, polypectomy, endoscopic mucosal resections), endoscopic ultrasound ± fine needle aspiration and lower GI endoscopic therapy (polypectomy ≥ 1 cm, endoscopic mucosal resections, laser or argon beam therapy, endoprosthesis insertion, dilatations).

### Inclusion and exclusion criteria

***Inclusion***

All diagnostic and therapeutic upper GI endoscopy, flexible sigmoidoscopy and colonoscopy in patients aged 16 years or above that had procedures with either no intravenous sedation or intravenous sedation with midazolam ± fentanyl between 1 July to 31 December 2004 and 1 March to 30 September 2006 were included in this study.

***Exclusion***

Any procedure performed outside the dates above, patients below 16 years of age, sedatives used other than midazolam or fentanyl for a procedure and any procedure requiring general anesthesia were excluded from this study. These criteria excluded only one patient from both years (both were therapeutic procedures; endoscopic ultrasound with fine needle aspiration in 2004 and oesophageal dilatation with nasojejunal feeding tube insertion in 2006) as there were no patients below the age of 16 years or no other sedatives/analgesics were used in 2 years. Endoscopic retrograde cholangiopancreatographies were not included in the data set in 2004 as it was subject to a separate national BSG audit and consequently was excluded in 2006 to allow unbiased comparisons with the data from 2004. This accounted for 197 and 210 ERCP procedures performed in 2004 and 2006, respectively.

### Statistical analysis

Comparisons of sedation doses used between the 2 years were made by using nonparametric statistics with the Mann–Whitney $U$ test with a significance level of less than 0.05 (i.e. $P < 0.05$).

To make comparisons of (i) endoscopic outcomes for specific midazolam dose (MD), (ii) endoscopic outcomes between 2004 and 2006 and (iii) endoscopic outcomes and procedural groups; two populations of patients were cross-tabulated with favourable versus unfavourable events and statistical differences analysed by using $\chi^2$ test with a significance level of less than 0.05 (i.e. $P < 0.05$). The mean (SD) is quoted throughout the text.

## Results

### Patient and procedure demographics

The mean age of the patients was 59.6 and 60.4 years of age in 2004 and 2006, respectively. The proportion of procedures using intravenous sedation was comparable

for both audit periods (53.5 vs. 56% for 2004 and 2006, respectively) (Table 1).

There were 32 and 36 different endoscopists performing procedures in 2004 and 2006, respectively. The mix of endoscopists' designation between the 2 years was comparable with consultant staff (28–30.5%) and trainees (34–36%), accounting for the largest numbers. Sixty-four percent ($n = 24$) of the endoscopists participated in both audits, and the change in trainees on the unit accounted for the turnover of endoscopists between the two time periods.

The endoscopists performing the majority of the diagnostic procedures in both years were the nurse endoscopists at 38 and 44% in 2004 and 2006, respectively, whereas the proportion of procedures performed by consultant staff, staff grades/hospital practitioners and trainees were comparable. The procedure mix was again comparable in both years with diagnostic gastroscopy making up more than 50% (56% in 2004 and 53% in 2006) and therapeutic 8–9% of the procedures.

**Table 1** Illustrates the patient and procedure demographics in 2004 and 2006

| | 2004 | 2006 |
|---|---|---|
| Age (years) | 59.6 | 60.4 |
| Percentage sedated (%) | 53 | 56 |
| Number of procedures | 7234 | 7071 |
| Procedure mix [no. (out of 100%)] | | |
| OGD | 4051 (56) | 3818 (54) |
| Sigmoidoscopy | 1592 (22) | 1626 (23) |
| Colonoscopy | 940 (13) | 1061 (15) |
| Therapeutics | 651 (9) | 566 (8) |
| Procedures performed by endoscopists' designation (out of 100%) | | |
| GP/family doctors | 8 | 6 |
| Consultant staff | 20 | 19 |
| Staff grades | 13 | 13 |
| Trainees | 21 | 18 |
| Nurse endoscopists | 38 | 44 |
| Endoscopist mix [no. (% total for year)] | | |
| GP/family doctors | 5 (16) | 5 (14) |
| Consultant staff | 9 (28) | 11 (30.5) |
| Staff grades | 2 (6) | 2 (5.5) |
| Trainees | 11 (34) | 13 (36) |
| Nurse endoscopists | 5 (16) | 5 (14) |

It shows that the percentage of patients sedated, the procedure types and the designation of endoscopists performing the procedures were reasonably well balanced between the 2 years.
GP, general practitioner.

### Changes in sedation practice

Overall, there was a 41% reduction in the mean MD administered between the two audit periods [mean (SD): 4.9 (2.5) vs. 2.9 mg (1.2); $P < 0.0001$]. The magnitude of dose reduction was similar (44%) in the subgroup of patients aged more than 70 years [4.3 (2.0) vs. 2.4 mg (1.0); $P < 0.0001$] (Fig. 1). The reductions in MD were observed across all procedure types as shown in Fig. 2. Furthermore, although in 2004, 19% (six of the 32) of endoscopists used a mean MD greater than 5 mg, no endoscopist had a mean MD greater than 5 mg ($P = 0.005$) in 2006 (Fig. 3).

Reductions were also observed in the overall fentanyl doses used between the two audit periods [77 (38.5) vs. 66.7 µg (27); $P < 0.001$] and reduction trends in the patients aged more than 70 years between the 2 years [67.7 (46) vs. 62.6 µg (24); $P = 0.06$] (Fig. 1).

### Endoscopic outcomes

#### *Procedure intolerance*

An increase was observed in the number of unsuccessful procedures because of patient intolerance from 0.1% in 2004 to 1.9% in 2006 ($P < 0.0001$; Fig. 4).

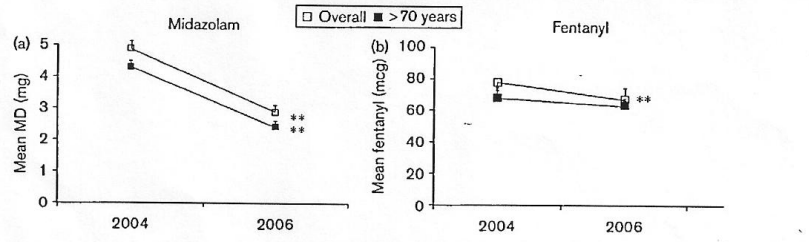
#### *Reversal agents' use*

The use of the reversal agents, flumazenil or naloxone, within the sedated patients was no different between the audit periods (0.6 vs. 0.7%; $P = 74$; Fig. 4).

#### *Thirty-day postprocedure mortality*

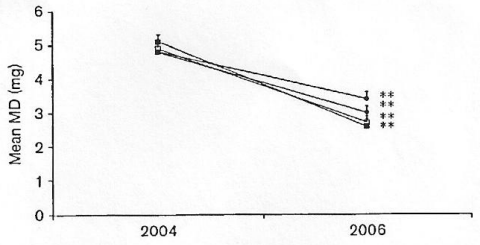
The mean age (SD) of patients dying within 30 days of endoscopy was 73.3 (17) and 74.5 (12) years in 2004 and 2006, respectively. Pneumonia, malignancy, cardiovascular

**Fig. 1**




Illustrates clear reductions in sedation doses (mean ± SE) used between 2004 and 2006 in all patients (□) and in patients above 70 years of age (■) in both midazolam doses (MD) (a) and fentanyl (b). $^{**}P < 0.0001$.

Fig. 2



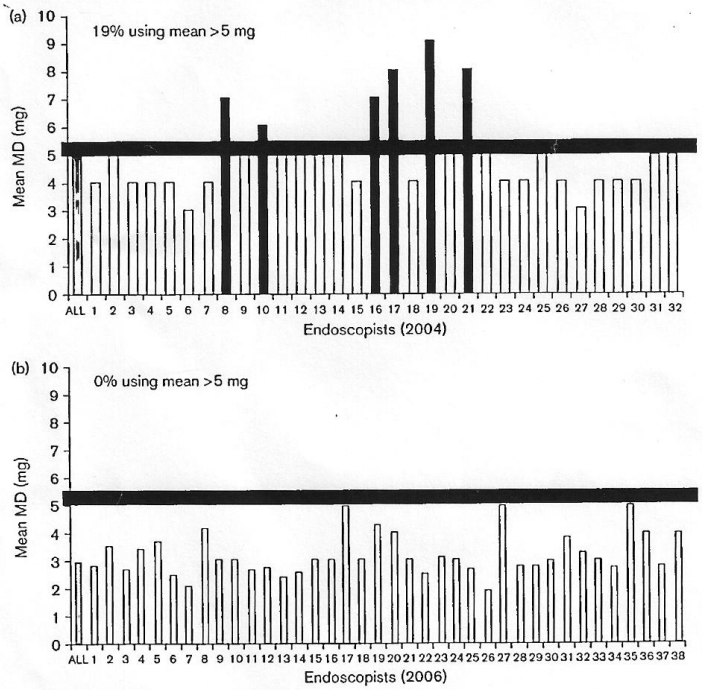

Shows the mean midazolam dose (MD) (mean±SE) used for gastroscopy (OGD) (●), therapeutics (○), flexible sigmoidoscopy (□) and colonoscopy (■) in 2004 and 2006. Again, significant reductions are seen in the mean dose of midazolam given across all procedure types. $^{**}P<0.001$.

disease and chronic liver disease were the most common causes of death for both years as recorded in section 1a of the death certificates as shown in Fig. 5. Of those that died, 70% (37 of 53) in 2004 and 82% (49 of the 60) in 2006 had received sedation.

The overall PPM (sedated and unsedated patients combined) was similar at 0.7 and 0.8% for 2004 and 2006, respectively ($P=0.5$). The PPM in sedated patients was also similar in both audit periods at 1.0 versus 1.3% ($P=0.23$; Fig. 2).

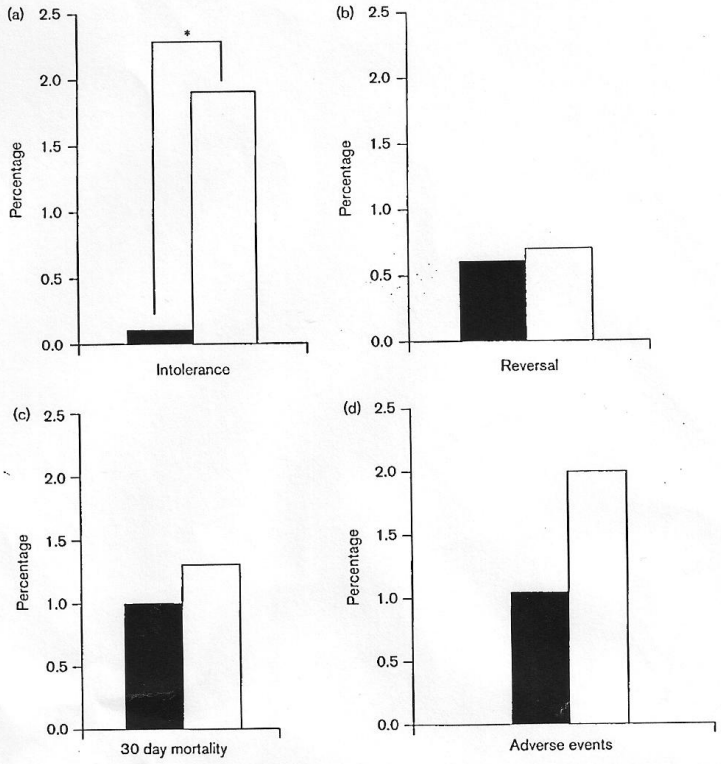
Compared with the overall patient population, those patients who died within 30 days of a procedure had received lower doses of sedation in 2004 [MD: 3.5 (1.8) vs. 4.9 mg (2.5); $P<0.0001$] and in 2006 [1.96 (1.3) vs. 2.9 mg (1.1); $P<0.0001$]. Furthermore, MD used in PPM

Fig. 3




Shows the mean midazolam dose (MD) used by each individual endoscopist during each 6-month audit period in 2004 (a) and 2006 (b). The initial grey bar on the left represents the overall mean for the unit in the respective years and the long black horizontal bar is placed at 5 mg, which is the dose taken by the national guidelines as the maximum dose to be given. The other vertical bars represent the mean dose used by each of the 32 and 38 endoscopists in 2004 and 2006, respectively. The endoscopists highlighted in black are those who have a mean greater than the national guidelines, 19% of endoscopists in 2004 used a mean above the national guidelines whereas none in 2006 used above this level.

Fig. 4




Shows the measured endoscopic outcomes for 2004 (■) and 2006 (□). (a) Shows patient intolerance, as the percentage of procedures that were not completed because of intolerability in sedated patients, which has increased in 2006. (b) Percentage of procedures where reversal agents were used in sedated patients with no differences seen. (c) Shows the percentage 30-day postprocedure mortality in sedated patients with no differences between the 2 years. (d) Shows the percentage overall adverse event rate for sedated patients with no differences between the 2 years. Although patient intolerability increased, there were no differences in other endoscopic outcomes between the 2 years. *$P<0.05$.

patients were significantly lower in 2006 when compared with 2004 ($P < 0.0001$) (Fig. 4).

When reviewing the procedure-specific PPM (Table 2), they were similar in both years for all procedural groups ($P = 0.53$ when comparing the groups with greatest difference). The PPM for therapeutic procedures, however, was 5–10 fold higher when compared with the other procedural groups (therapeutic PPM 3.1–3.5% vs. diagnostic PPM 0.3–07%, $P = 0.0001$ when comparing therapeutics with diagnostic procedural groups with the least difference).

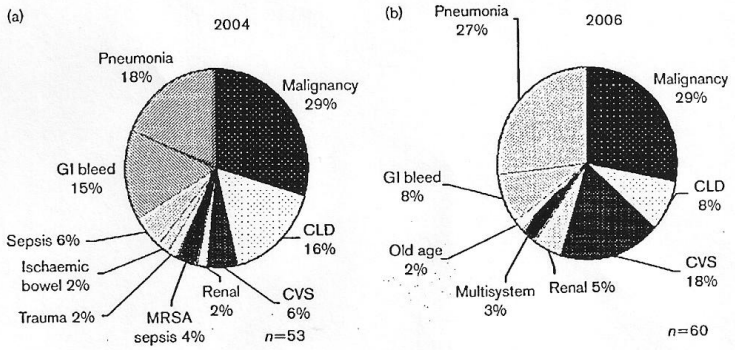
***Elderly patients mortality***

A nonsignificant trend towards increased PPM was observed in sedated patients aged 70 years or above (elderly) in 2006 compared with 2004 (4.1% compared with 2.7%; $P = 0.06$; Fig. 6). When comparing elderly patients that received MD $\leq 2$ mg versus greater than 2 mg, PPM was not significant in 2004 (0.9 vs. 1.8%, respectively; $P = 0.22$) but was higher in the group that had received greater than 2 mg in 2006 (1.2 vs. 3%; $P = 0.01$). However, for the combined data sets PPM was not significantly higher (1 vs. 2.3%; $P = 0.5$; Fig. 6).

***Total adverse events***

No difference in the number of adverse events in the sedated patients between the 2 years with rates of 1.7% in 2004 and 2% in 2006 ($P = 0.44$; Fig. 4) was observed. The audit in 2004 found no significant differences in total adverse events in those patients who received

Fig. 5




Shows the causes of death (1a on death certificate) for those patients who died within 30 days of their endoscopy in 2004 (a) and 2006 (b). The most common primary cause of death was malignancy, pneumonia, cardiovascular causes, chronic liver disease, and gastrointestinal bleeds. CLD, chronic liver disease; CVS, cardiovascular; GI, gastrointestinal; MRSA, methicillin-resistant *Staphylococcus aureus*.

Table 2 Illustrates the 30-day PPM both overall and procedure specific

| | 2004 | 2006 |
|---|---|---|
| Overall PPM (%) | 0.7 | 0.8 |
| Procedure-specific PPM (%) | | |
| OGD | 0.7 | 0.7 |
| Sigmoidoscopy | 0.3 | 0.5 |
| Colonoscopy | 0.3 | 0.3 |
| Therapeutics | 3.1 | 3.5 |

Although PPM is similar across both years, it is significantly greater by 5–10 fold for therapeutic procedures.
OGD, gastroscopy, PPM, postprocedure mortality.

MD $\leq$ 5 mg and those receiving MD greater than 5 mg (1.0 vs. 1.4%, respectively; $P = 0.4$). The adverse events data for 2006 comparing these two doses of MD were not analyzable because of small number of patients receiving MD greater than 5 mg patients in this year after implementing successful interventions.

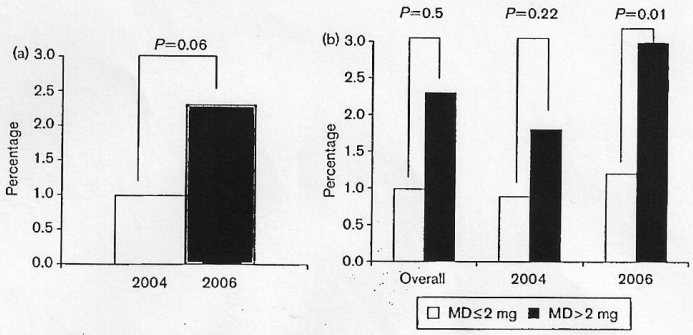
## Discussion

Our study has shown that the successful implementation of a number of measures to ensure safer sedation practice was effective in reducing the doses of sedation used in endoscopy but this did not, however, translate into improvements in endoscopic outcomes by our criteria. Moreover, one of the consequences of this 'safer sedation practice' may have been increased unsuccessful procedures because of poor patient tolerance.

Evidence from small observational and controlled studies have shown that significant hypoxia, tachycardia and arrhythmias occur during upper and lower endoscopy in both sedated and unsedated patients with no significant differences between the two groups [4]. Other studies have shown that the incidence of hypoxia and desaturation was significantly increased in sedated patients but that this effect was abolished by the administration of supplementary nasal oxygen [21], which is now the standard practice in most endoscopy units [6,16]. Cardiovascular effects during gastroscopy seem to include more pronounced changes in blood pressure and heart rate in sedated patients [21–23], but healthy volunteer studies seem to suggest that this increased cardiac stress during endoscopy is similar in both sedated and unsedated patients [24]. Interestingly, although cardiac ischaemia has been shown to occur in sedated patients with known coronary heart disease during endoscopy [25], the incidence may well be less than in unsedated patients [26]. In addition, a small randomized controlled trial (RCT) of patients undergoing diagnostic upper GI endoscopy showed that there were no differences in adverse events between sedated and unsedated patients and that there were trends towards faster and easier procedures in the former group of patients [4].

Within the literature, there are no conclusive studies showing that either higher sedation doses *per se* or sedation alone is responsible for worse endoscopic outcomes. However, one of the conclusions from NCEPOD was that 14% of patients that died within 30 days of a procedure were judged to have excessive doses of sedation and thus implying that high sedation doses contributed to subsequent mortality [6]. A number of our findings did not seem to support this conjecture but, rather, suggested that higher sedation doses were not associated with worse endoscopic outcomes, at least by our criteria. These include: first, the overall outcomes in 2004 and 2006 were similar despite a substantial reduction in sedation doses used. Second, patients who

Fig. 6




Shows the postprocedure mortality (PPM) in patients more than 70 years of age (elderly) who received sedation. (a) Shows a trend towards higher PPM in 2006 than 2004 after the introduction of safer sedation practice. (b) Shows PPM in patients that received midazolam dose (MD) greater than 2 mg and MD ≤ 2 mg when the data is combined (overall), in 2004 and in 2006. There seems to be a doubling of mortality in MD greater than 2 mg patients but this is not significant overall.

were given MD greater than 5 mg, and thus considered to have received doses in excess of routinely recommended limits by the Royal College of Anaesthesia and BSG guidelines [2,16], had no worse outcomes than those patients who were given the recommended doses. Finally, 19% of endoscopists in 2004 used mean MD greater than 5 mg, yet our data suggest no worse outcomes in this year compared with 2006, where no endoscopists had a mean MD greater than 5 mg.

Our study found an unexpected trend in elderly patients, where the overall mortality was higher in 2006 than in 2004. The National Patient Safety Agency bulletin and Lord *et al.* [14,15], performed a subanalysis for elderly patients (patients 70 or above years of age) of the NCEPOD data and the East Anglia database, which were contrary to our findings by suggesting worse outcomes with higher doses of sedation. After this publication, a national guidance was issued regarding maximum sedation doses in elderly patients recommending MD ≤ 2 mg [10,14,15]. Although the sedation doses used in our study in elderly patients were much lower in 2006 compared with 2004, it may be argued from the above reports that even lower MD of 2.4 mg was still too high in these patients. Although it seems illogical how this could explain our results of a reverse trend in mortality in elderly patients, we went on to carry out a subanalysis in sedated elderly patients by dividing them into MD ≤ 2 mg and MD greater than 2 mg. Overall, we found no significant increase in PPM, albeit subanalysis of the 2006 data did reveal an apparent increase. This partly supports the NPAS recommendations of special considerations to this age group by using MD ≤ 2 mg.

Interestingly, the MD used in the PPM patients in our study were much lower than the overall mean in both 2004 and 2006 and the mean dose was lower in the PPM patients in 2006 than in 2004. This suggests that the endoscopists do adapt their practice in potentially vulnerable patients (the mean age of these patients was above 70).

Our study has a number of limitations including those expected from an audit methodology. (i) It was not an RCT and so the results should be interpreted cautiously. There are no large RCTs investigating the effects of varying sedation dosage regimens on outcomes for various endoscopic procedures. Our study included a range of diagnostic and therapeutic procedures of varying complexity and found a maximum 2% adverse event rate in over 14 000 procedures. This makes the design and conduct of adequately powered trials difficult – it would certainly be ethically difficult to justify a trial that randomly assigned patients undergoing therapeutic procedures to be restricted, or no sedation or alternatively to higher-than-recommended doses. Furthermore, the literature suggests that RCTs involving sedation in endoscopic procedures are undesirable from a patient, nursing and medical perspective [27,28]; (ii) possibility of a type-2 error (a failure to detect a real difference owing to low numbers of events) because of our low rates of adverse events (1.5–2.0%) and PPM (1.0–1.3%), which are similar to those reported in other studies [5,29]. Interestingly, although no statistical differences were detected in our outcomes between the 2 years, the numerical trends were in the opposite direction than expected. Hence, type-2 errors, if anything, would be masking an increase in poor

outcomes, that is, safer sedation practice worsened endoscopic outcomes, assuming the simple cause–effect link between doses of sedation and the specified outcome measures; (iii) it is a single-center teaching hospital experience. However, over 30 different endoscopists from multidisciplinary backgrounds and designation participated in both audits, thus making it a credible representation of endoscopic practice in the UK; (iv) PPM may not be the best measure of mortality. We preferred this broad definition of any death occurring within 30 days of an audited endoscopic procedure rather than endoscopy-specific related mortality as used by NCEPOD [6]. This is because, first, PPM's ease of determination as a robust end point and second, we found that determining endoscopy-related mortality *per se* extremely difficult to judge retrospectively (although the causes of death in all our patients were ascertained) because of subjectivity, hence open to interpretation/bias in our hands; (v) other potentially important end points when assessing endoscopic outcomes such as nonfatal morbidity related to endoscopy (e.g. chest infections/pneumonia), length of stay and patient satisfaction were not measured in our study.

The strengths of our study include: (i) the large number of mixed procedures audited ($n = 14\,305$ cases); (ii) the patient and procedure demographics were well matched between the two audits; (iii) the PPM for our therapeutic procedures, which was unsurprisingly up to 10-fold higher than the diagnostic procedures and were similar to the NCEPOD audit; (iv) substantial reductions in mean sedation doses were achieved ( > 40%) between the two audit periods; (v) both favourable and unfavourable outcomes were compared.

Our study did convincingly show that the introduction of effective sedation policies, procedures and protocols can substantially reduce the amount of sedation used by endoscopist across the drugs used and procedural groups. One of the detrimental effects of this was that procedure completion was, however, reduced because of patient intolerance. Although our method of determining patient intolerance may have been crude, this negative outcome is in keeping with other studies [3–5,30] and seems logical as lower doses of midazolam and fentanyl are likely to cause less sedative effects.

In conclusion, our study has shown that effective interventions can reduce the amount of sedation used in endoscopy. However, despite the various limitations of this study, it also suggests that this may not translate into improved endoscopic outcomes and, may instead, have a negative impact on procedure tolerance. It is wise to limit the risks of sedation by adopting the safest, best practice but the evidence base for stipulating specific dosage thresholds is not strong and more research is needed in this controversial area.

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# All-cause mortality after first ERCP in England: clinically guided analysis of hospital episode statistics with linkage to registry of death

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**Background:** All-cause death within 30 days of ERCP is a candidate indicator of care, but institutional-level statistics require careful interpretation. National-scale, population-based outcome studies of unselected patients undergoing ERCP are needed to define expected levels of real-world mortality risk and the case-mix factors that predict poor outcome.

**Objective:** To develop methods for analyzing administrative data for English hospitals with linkage to death registration to study all-cause mortality after first ERCPs and explore predictors of death and institutional variation.

**Design:** Hospital episode statistics for 2006 to 2007 and 2007 to 2008 were linked to the statutory death register. First ERCP episodes were extracted and analyzed for demographic characteristics, admission method, diagnoses, and comorbidities. Additional linkages identified the last-coded diagnosis before death. Factors associated with 30-day death were identified by univariate and multiple logistic analyses. Pilot data and a survey were sent to clinicians at each institution. Crude and case-mix adjusted mortality were analyzed at the institutional level.

**Main Outcome Measurements:** Death within 30 days of the first ERCP procedure.

**Results:** We analyzed 20,246 first ERCPs from 2006 to 2007 and 20,422 from 2007 to 2008. Diagnostic profile: gallstone related 57.3%; cancer 12.6%; gallstone and cancer 2%; others 28.1%. All-cause 30-day death was 5.3% (2.4% in non-cancer cases). Predictors of 30-day death (adjusted odds ratio [OR]) were as follows: age (OR 6.2, for ≥85 years vs <55 years), male sex (OR 1.2 vs female), emergency admission (OR 2.0 vs elective), cancer (OR 8.6 vs no cancer), and non-cancer comorbidity (OR 1.5 vs none). A mortality risk estimator (look-up table) based on pooled data for >40,000 first ERCPs is provided. Specific procedural complication codes were identified in 1.2% of deaths (0.06% of ERCPs). At the institutional level, analysis of mortality rates was within expected statistical funnel limits, and we found no correlation with ERCP volume (Pearson $r = -0.05$; $P > .05$).

**Limitations:** The completeness and accuracy of coding may vary between different hospitals. Routine coding does not capture information about procedural complexity or severity of illness.

**Conclusion:** Linkage analysis of hospital episode statistics data for England provides a powerful tool for studying mortality risk after ERCP on an unselected and truly nationwide scale. Institutional-level statistics suggest that the mortality risk for patients requiring ERCP was comparable across English hospitals. (Gastrointest Endosc 2011;74: 825-33.)

*Abbreviations: HES, hospital episode statistics; NHS, National Health Service.*

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ERCP is an advanced technique with a vital role in treating pancreaticobiliary diseases.[1] In selecting patients for ERCP, clinicians must balance benefits against disease prognosis, comorbidity, and procedural risks. Complications such as pancreatitis, sepsis, bleeding, or perforation occur in 5% to 10% of cases.[2] An independent United Kingdom report examining deaths after ERCP concluded that most mortality reflects expected disease progression.[3] However, the report suggested that ERCP was futile in 68% of deaths and made recommendations for optimizing patient selection and care.[3]

British endoscopy units are encouraged to audit 30-day mortality as part of their quality assurance program.[4] However, the National Health Service (NHS) lacks a validated system for routinely linking specific procedures to subsequent death. Hence, expected levels of mortality for unselected patients requiring ERCP are poorly defined. A survey of 66 English hospitals reported all-cause 30-day mortality at 2.7% after first ERCP but covered less than half of institutions and only a sample of the total caseload.[5] Knowledge of real-world, 30-day mortality for patients requiring ERCP is limited, and better understanding of predictors of survival would inform the process of case selection and consent. Disclosure of risks to patients requiring ERCP is inconsistent both in the United Kingdom and in other countries[6,7] and is a common theme in litigation claims after poor outcomes.[8]

Comparison of hospital mortality rates is controversial.[9] In England, analysis of routine administrative data has provided insights into inequalities in mortality[10-12] and has achieved a predictive value similar to that of clinical databases for some surgical procedures.[13] Case-mix adjustment based on routine coding attempts to legitimize interinstitutional comparisons[14] but remains controversial.[9,14,15] This article reports the application of linkage methods to administrative data for English NHS hospitals to study mortality in patients requiring ERCP, defining simple predictors of outcome and exploring institutional variation with direct feedback from local gastroenterologists.

**Take-home Message**

- This national scale, population-based study shows that the overall 30-day risk of death in patients requiring a first ERCP in England is 1 in 20.
- As expected, increasing age, underlying cancer, comorbid disease, and ERCP during emergency hospital admission are the major predictors of death.

## MATERIALS AND METHODS

### Hospital episode statistics

All NHS trusts in England submit information to a central data warehouse about each admission (including outpatient procedures coded as elective "day cases").[16] NHS trusts are provider organizations that provide secondary care services at one or more hospital sites. These data, or hospital episode statistics (HES), serve a variety of administrative/accounting purposes and contain a limited clinical dataset including a primary diagnosis and up 13 secondary diagnostic codes recorded at the time of discharge (based on the ICD-10 classification) and procedures undertaken (using OPCS-4 procedure codes). For this study, we obtained two consecutive data years (2006-2007 and 2008-2009), each containing over 10 million care episodes in medical and surgical specialties for adult patients (>16 years).

### Data extraction, linkage to death registry, and analysis

We extracted all episodes containing ERCP procedures (OPCS-4 J codes 381-2; 388-9; 391; 398-9; 401-9; 411-4; 418-9; 421-5; 428-9; 431-2; 431-3; 438-9; 441; 448-9; 451-3; 458-9). Age was divided into 5 categories (<55, 55-64, 65-74, 75-84, and 85+ years). ERCPs were classified as performed during either an elective (including day cases) or non-elective (emergency) admission by using relevant admission variables. Diagnosis fields were used to derive categorical variables for ERCP indication (cancer, gallstones, or other) by using combinations of primary and lower-order diagnoses to identify all relevant ICD-10 codes contained within the ERCP episode. Recognizing the potential for variability in the precision and depth of coding of secondary diagnoses,[9,15] we adopted a simple binary variable to identify the presence or absence of any non-cancer comorbidity listed in the Charlson index.[17] The dataset for the project allowed for linkage between HES data and death registry information (Office of National Statistics) to establish alive-dead status and date of death. Outcome variables for all-cause death at 7 and 30 days from procedure date were generated. For cases of 30-day mortality, we extracted all inpatient care episodes before death from the HES dataset, identified the patient's last hospital admission, determined whether death was in or out of the hospital, and analyzed the last-recorded primary diagnosis.

### Validation of data quality

HES data have been used to study in-hospital mortality for several conditions.[9-13] Linkage to the death registry could improve mortality capture by including deaths outside of the hospital. We explored the validity of coded data for ERCPs in several ways. First, we compared the case mix of ERCP cases identified from HES data with that reported in a large survey of English practice.[5] Second, in our own hospital, we compared our own records for 30-day post-ERCP deaths with the anonymous national data and inferred from age, sex, diagnosis, and procedure date if there was consistency. Third, our engagement with front-line teams sought feedback on the overall approach

to analysis and the data coded and submitted by their local institutions. A steering group that included representation from the British Society of Gastroenterology, the NHS Information Centre, medical and surgical gastroenterologists, and public health experts oversaw the methodology and remained involved in the analysis, feedback, and review process.

### Engagement of clinicians

We identified local gastroenterologists (consultants) from a combination of the British Society of Gastroenterology and NHS electronic records, augmented by e-mail and telephone requests to individual units. Pilot analyses of institutional-level comparative data were sent out electronically to each clinician along with a questionnaire and pilot data presented at a national conference.[18] Relevant questionnaire items are given in the Results section. The questionnaire feedback was used to inform the final analytical approach, further interrogate the data, and correct discrepancies.

### Statistical analyses

HES data were stored, manipulated, and analyzed in SPSS statistical package (SPSS Inc, Chicago, Ill). Factors associated with 30-day mortality were identified by univariate analysis and binary logistic regression models. Funnel plots of the institutional-level data were plotted by using analytical tools from the Association of Public Health Observatories.[19]

## RESULTS

### Patient population

ERCPs were coded by 150 acute NHS trusts. We retrieved 37,386 ERCP procedures for 2006 to 2007, of which 410 (1.1%) were excluded owing to invalid data entries (eg, invalid dates or missing data fields). Procedure numbers were similar for 2007 to 2008 (38,108 ERCPs; 518 [1.4%] invalid records). Based on questionnaire feedback, we focused analysis on first ERCP procedures. Within each data year, patients who underwent their first ERCP procedures between July 1 and March 31 were selected (quarters 2-4) to ensure that no earlier ERCP was performed within ≥3 months of the index procedure. This yielded a study population of approximately 20,000 consecutive first ERCP cases selected from each year.

There were 712 individual ICD-10 codes recorded in the primary diagnosis field for the episode of care containing a first ERCP procedure. The proportion of patients with a gallstone-related condition in the first (primary) diagnosis field was 52.1%, benign pancreatic disease 6.9%, pancreatic malignancy 6.2%, biliary malignancy 3.6%, other forms of cancer 3.1%, other benign hepatic or extrabiliary GI conditions 2.5%, other benign biliary or gallbladder disorders 0.6%. The remaining 20% of cases had less specific codes in the primary position, the 3 most common being obstruction of bile duct (K83.1), other specified diseases of biliary tract (K83.8), and cholangitis (K83.0). However, additional diagnoses relevant to ERCP indication were identified in secondary and lower-order diagnostic fields. Hence, we developed methods to screen all diagnostic code positions for each patient for the presence of any relevant gallstone-related or cancer-related codes, based on listings approved by the steering group. This resulted in a binary variable for the presence or absence of gallstones and for relevant cancers for each patient, coded at any diagnostic position.

Table 1 summarizes patient characteristics. The cohorts from 2006 to 2007 and 2007 to 2008 were almost identical. The most common coded diagnoses compatible with ERCP indication were gallstone related (58%). Relevant cancers were coded in 14% to 15% of patients (pancreatic cancer accounted for 49% of all malignancies). Approximately one-fourth of all patients were coded as having one or more comorbid benign conditions listed in the Charlson index.

### Factors associated with all-cause death after first ERCP in England

All-cause mortality within 7 days of first ERCP was <1.5% and at 30 days was 5.3% (Table 1). Cases with a cancer diagnosis accounted for 58.5% of deaths within 30 days in 2006 to 2007 and 61.2% in 2007 to 2008. Of patients without a cancer diagnosis coded, all-cause 30-day mortality was 2.4% in both years.

Univariate analysis of the 2006 to 2007 cohort showed that those dying within 30 days were older (mean [SD] age 76 [± 12] vs 66 [± 17] years; $P < .001$), included more men (49.9% vs 40.2%; $P < .001$), more patients treated during an emergency admission (74.1% vs 51.9%; $P < .001$), more cases of cancer (58.5% vs 12.1%; $P < .001$), and more patients with non-cancer comorbidities (36.1% vs 21.6%; $P < .001$) than patients still alive. Analyses for 2007 to 2008 was almost identical. Comparison of pancreatic versus hepaticobiliary cancers showed that 30-day mortality was the same (21.3% vs 21.6%; $P = .76$) and Kaplan-Meier survival curves were identical—hence, no further subgrouping by specific cancer type was undertaken in the present analysis.

Binary logistic regression analysis confirmed age, sex, emergency admission, cancer, and non-cancer comorbidity as independent predictors of 30-day mortality (Table 2). As expected, cancer was the strongest predictor with an 8-fold increase in adjusted odds of death compared with non-cancer cases. Patients requiring ERCP during an emergency admission had a 2-fold increase in odds of death compared with elective cases.

The optimized model containing the 5 predictor variables was found to predict death with 75.6% sensitivity and 77.9% specificity when tested internally on the same dataset (ie, the 2006 to 2007 data). When variables were retested against the 2007 to 2008 dataset, performance was comparable with a sensitivity of 79.6% and specificity of 77.1%.

TABLE 1. Patient characteristics and crude, all-cause mortality for first ERCPs performed in England during the second, third, or fourth quarters of the 2006 to 2007 and 2007 to 2008 data years

| | 2006-2007 (Q 2-4) | 2007-2008 (Q 2-4) |
|---|---|---|
| Patients, no. | 20,246 | 20,692 |
| Female sex, no. (%) | 12,001 (59.3) | 12,194 (58.9) |
| Age, mean (± SD), range, y | 66.2 (± 17), range 16-105 | 66.6 (± 17), range 16-108 |
| Admission type, no. (%)* | | |
| Elective | 9476 (46.9) | 9935 (48.0) |
| Not elective (emergency) | 10,750 (53.1) | 10,757 (52.0) |
| Diagnosis, no. (%)† | | |
| Gallstones (no cancer) | 11,595 (57.3) | 11,992 (58.0) |
| Cancer (no gallstones) | 2552 (12.6) | 2644 (12.8) |
| Cancer and gallstones | 401 (2.0) | 441 (2.1) |
| Other diagnoses | 5698 (28.1) | 5615 (27.1) |
| Any non-cancer comorbidity, no. (%) | | |
| Absent | 15,717 (77.6) | 15,678 (75.8) |
| Present | 4529 (22.4) | 5014 (24.2) |
| Died within 7 d of first-recorded ERCP, no. (%) | 253 (1.3) | 286 (1.4) |
| Died within 30 d of first-recorded ERCP, no. (%) | 1078 (5.3) | 1093 (5.3) |

*Q*, Quarter; *SD*, standard deviation.
**Elective* refers to a planned day case or elective admission for ERCP, whereas *not elective (emergency)* refers to an ERCP performed during an unplanned acute hospitalization.
†Diagnostic category is based on screening primary and lower-order diagnostic fields for ICD-10 codes consistent with gallstone-related conditions or relevant cancers.

We performed separate regression analyses for cancer and non-cancer cases (Table 2). In non-cancer cases, the variables of increasing age, male sex, emergency admission status, and non-malignant comorbidity retained significant independent associations with death. However, among cancer cases, only advanced age and emergency admission status were associated with significantly increased odds of death, illustrating the dominant influence of cancer on prognosis.

HES data contains a socioeconomic variable, the index of multiple deprivation, which allows patients to be ranked according to area of residence (most deprived to least deprived). However, for patients undergoing first ERCP, this variable did not demonstrate a significant association with 30-day mortality.

## Analysis of last-coded primary diagnoses before death (2006 to 2007 data)

Of 1078 patients dying within 30 days, 378 (35.1%) remained hospitalized after ERCP and died during that admission. Providers discharged 185 patients (17.2%) after the original ERCP who later died outside of the hospital. Providers discharged 515 patients (47.8%) from the hospital who were later readmitted before death (400 died during the readmission, and 115 were discharged and later died out of the hospital).

The last-coded primary diagnoses are summarized in Table 3. In approximately two-thirds of cases, the last primary diagnosis before death was a condition for which the original ERCP would be indicated, including pancreatic or hepatobiliary malignancies, gallstones, benign pancreatic diseases, or other nonspecific biliary-related codes such as obstruction of bile duct or cholangitis. A range of other cancers were coded, including tumors of the GI tract and tumors of some non-GI sites. In the remainder of cases, the primary diagnosis recorded before death was neither a pancreaticobiliary or liver condition nor a form of cancer. Non-GI diagnoses included respiratory (eg, pneumonia), cardiac (eg, myocardial infarction), neurologic (eg, stroke), and renal conditions (eg, acute renal failure). A small number of diagnoses were suggestive of mortality entirely unrelated to the reason for ERCP or to the procedure itself—this included orthopedic codes (eg, fractures) suggestive of trauma (n = 9) and ruptured abdominal aortic aneurysm (n = 2). These codes were present in only 1.0% of deaths identified in the present study.

TABLE 2. Factors associated with all-cause mortality within 30 days of the first ERCP procedure, binary logistic regression analysis of 20,246 first procedures performed in England during 2005 to 2007*

| Predictor variable | All patients (n = 20,246) OR | 95% CI | Benign diagnosis only (n = 17,293) OR | 95% CI | Cancer diagnosis (n = 2953) OR | 95% CI |
|---|---|---|---|---|---|---|
| Age, y | | | | | | |
| <55 | 1 | -- | 1 | -- | 1 | -- |
| 55-64 | 2.20† | 1.59-3.03 | 2.67† | 1.61-4.41 | 1.49 | 0.97-2.29 |
| 65-74 | 2.34† | 1.73-3.17 | 3.49† | 2.20-5.53 | 1.36 | 0.91-2.04 |
| 75-84 | 3.79† | 2.84-5.05 | 5.69† | 3.68-8.80 | 2.17† | 1.46-3.22 |
| >84 | 6.16† | 4.58-8.30 | 10.76† | 6.94-16.70 | 2.77† | 1.82-4.21 |
| Sex | | | | | | |
| Female | 1 | -- | 1 | -- | 1 | -- |
| Male | 1.22† | 1.07-1.39 | 1.46† | 1.20-1.77 | 1.01 | 0.84-1.21 |
| Admission type | | | | | | |
| Elective | 1 | -- | 1 | -- | 1 | -- |
| Not elective (emergency) | 2.02† | 1.74-2.34 | 2.32† | 1.85-2.89 | 1.76† | 1.44-2.15 |
| Non-cancer comorbidity‡ | | | | | | |
| Absent | 1 | -- | 1 | -- | 1 | -- |
| Present | 1.47† | 1.28-1.69 | 1.94† | 1.59-2.36 | 1.12 | 0.92-1.37 |
| Cancer diagnosis | | | | | | |
| Absent | 1.00 | -- | N/A | N/A | N/A | N/A |
| Present | 8.61† | 1.28-1.69 | | | | |

*OR*, Odds ratio; *CI*, confidence interval; *N/A*, not applicable.
*Adjusted ORs with 95% CIs. Reference case for each predictor variable is the first category (eg, for age group, reference category is <55 years of age).
†Statistically significant odds ratio ($P < .05$).
‡Presence of one or more Charlson comorbidities (excluding cancer-related codes).

Only rarely was a diagnosis recorded that would be compatible with a specific postprocedural technical complication (n = 13). These codes were: accidental puncture and laceration during a procedure (T812); infection after a procedure, not elsewhere classified (T814); mechanical complication of a GI prosthesis (T855); infective or inflammatory reaction related to another internal prosthetic device (T857); other complications of internal prosthetic devices (T858); and perforation of the esophagus (K223). These codes were present in only 1.2% of cases of death and represent just 0.06% of all first ERCPs. Interestingly, a large-scale study of the incidence and risk factors for complications of ERCP from one major U.S. center (n = 11,497 patients) reported fatal complications at a rate of 0.06%.[20]

## A bedside tool for estimating mortality risk after first ERCP

Pooling of data from both years (n = 40,938 patients) generated a look-up table for estimating 30-day mortality according to admission method, cancer diagnosis, presence of major non-cancer comorbid illness, and age group (Table 4). Mortality in the lowest risk category was just 0.4% (elective cases, <55 years old, without comorbidity, and undergoing ERCP for a benign indication). Our linkage analysis of last-recorded primary diagnosis cannot distinguish reliably between deaths related to progression of underlying disease, additional interventions, unrelated chance events, or procedural complications. However, a pooled estimate of procedure-related mortality for ERCP from 21 published surveys (16,855 patients in total) produced a figure of 0.33%[2] and was 0.4% in the English survey.[5]

At the other end of the risk spectrum, mortality was almost 40% for the oldest age group admitted as an emergency with underlying cancer and comorbidity. Intervention in the highest-risk cases might be deemed futile if only deaths are audited,[3] but 60% of the poorest-risk cases

TABLE 3. Last coded primary diagnosis before death*

| Diagnostic category | No. | % deaths (n = 1078) | % total ERCPs (n = 20,246) |
|---|---|---|---|
| Hepatobiliary or pancreatic malignancy | 466 | 43.2 | 2.30 |
| Other malignancy | 150 | 13.9 | 0.74 |
| Gallstone-related diseases | 97 | 9.0 | 0.48 |
| Other hepatobiliary or pancreatic diseases | 163 | 15.1 | 0.81 |
| Other GI diseases (including infection) | 51 | 4.7 | 0.25 |
| Respiratory diseases (including infection) | 33 | 3.1 | 0.16 |
| Cardiovascular diseases | 29 | 2.7 | 0.14 |
| Renal diseases | 15 | 1.4 | 0.07 |
| Neurological diseases | 7 | 0.6 | 0.03 |
| Septicemia | 36 | 3.3 | 0.18 |
| Trauma/orthopedic diseases | 7 | 0.6 | 0.03 |
| Procedural complication codes | 13 | 1.2 | 0.06 |
| Miscellaneous other | 11 | 1.0 | 0.05 |

*Data for 1078 patients dying within 30 days of first ERCP performed in England (total ERCP cases, n = 20,246). Patients are categorized according to the primary diagnosis (ICD-10 code) recorded for their last admitted episode of care before death.

TABLE 4. All-cause mortality within 30 days of first ERCP according to admission method (elective or emergency), cancer diagnosis, presence of any non-cancer comorbidity (based on charlson index), and age group: % [n]*

| Emergency | Cancer | Comorbidity | <55 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|
| No | No | No | 0.4 | 0.7 | 1.2 | 1.6 | 2.4 |
| No | No | Yes | 0.7 | 1.0 | 1.5 | 2.4 | 6.2 |
| No | Yes | No | 9.4 | 12.4 | 12.3 | 14.2 | 22.7 |
| No | Yes | Yes | 9.4 | 19.0 | 15.5 | 21.3 | 27.3 |
| Yes | No | No | 0.2 | 1.4 | 2.2 | 3.9 | 7.9 |
| Yes | No | Yes | 1.9 | 3.3 | 4.2 | 8.3 | 11.3 |
| Yes | Yes | No | 16.0 | 20.0 | 21.4 | 27.2 | 30.6 |
| Yes | Yes | Yes | 14.3 | 20.6 | 23.2 | 33.2 | 39.8 |

*Pooled data for quarters 2 through 4 of 2006 to 2007 and 2007 to 2008 for acute hospital trusts in England (n = 40,938 patients).

survive beyond 30 days. ERCP has a key role in palliating malignant biliary obstruction, and these data could inform realistic discussions between clinicians and patients.

## Validation of the routine administrative data

The patient characteristics are comparable with those of a previous English survey of ERCP (mean age 65 years, women 57%, suspected diagnosis, ductal stones 54%, and malignancy 20%).[5] However, all-cause mortality was higher in our study at 5.3% (vs 2.7%).[5] The earlier survey may have missed higher-risk cases because informed consent was required—mortality among nonparticipating patients in that survey was 5.6%.[5] In our study, 16,026 cases underwent ERCP at a hospital that had participated in the previous survey, and 24,912 cases were treated at a nonparticipating hospital, with no difference in 30-day mortality (5.37% vs 5.26%; $P > .05$). We conclude that the higher rate of all-cause death in the present study reflects more complete case ascertainment, including critically ill and/or palliative cases.

Our comparison of anonymous HES data with local data within one trust confirmed that there was a corre-

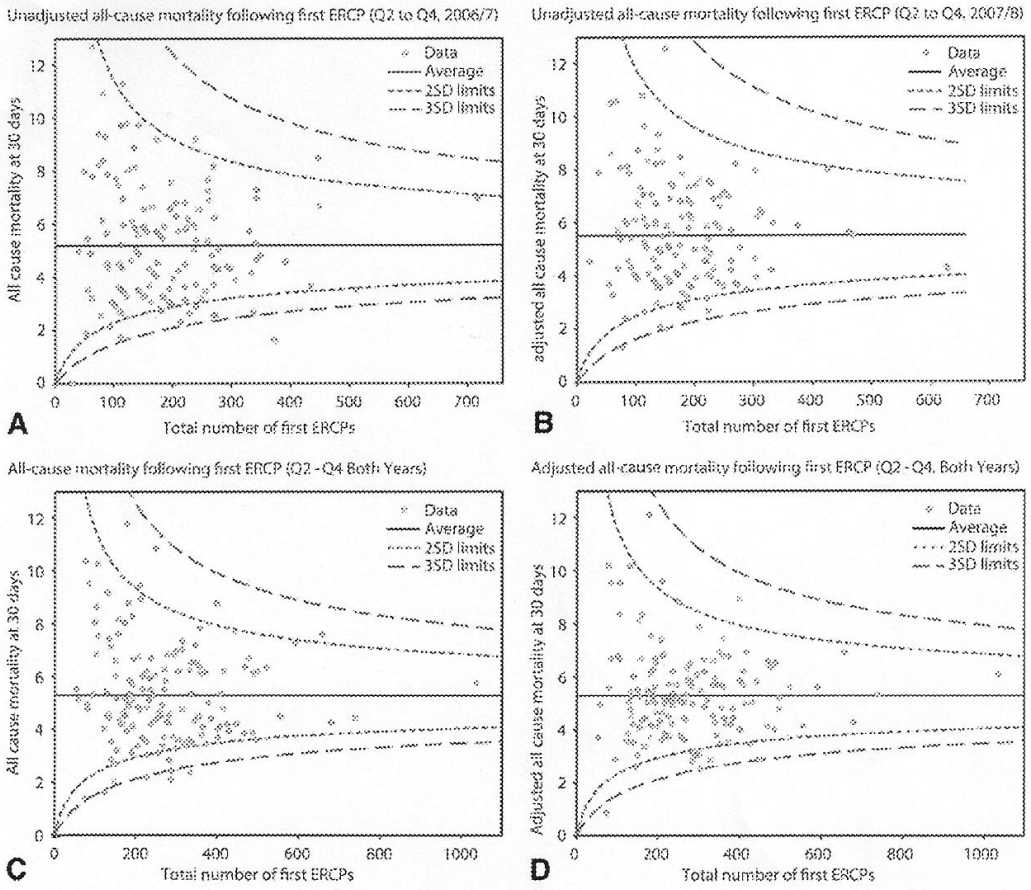


**Figure 1.** Funnel plot of all-cause mortality within 30 days of first ERCP procedure versus number of procedures for English hospitals (n = 150 National Health Service trusts). *Q,* quarter; *SD,* standard deviation. **A,** Unadjusted mortality data for 2006 to 2007 (n = 20,246 patients). **B,** Unadjusted mortality data for 2007 to 2008 (n = 20,692 patients). **C,** Pooled unadjusted mortality data from both years combined. **D,** Case-mix adjusted mortality data from both years combined (based on look-up tables by age group, emergency admission status, cancer diagnosis, and non-cancer comorbidity variables).

sponding case for each recorded death (n = 20), implying that the mortality linkage processes between HES and the Office of National Statistics (ONS) are reliable and that this study is examining genuine cases of post-ERCP mortality.

## Questionnaire feedback

Questionnaires were obtained from 65% of institutions (114 clinicians from 98 trusts). ERCP counts were judged accurate by 66%, but 93% expressed concerns about incomplete local capture. Local audit of mortality was being undertaken by only 65% of respondents, but 74% indicated that mortality figures appeared valid for their unit. Seventy-seven percent agreed that crude mortality data were potentially useful to local teams, and 91% wished to have routine access to linked HES data to identify mortality cases. However, 45% suggested modifications to the pilot analyses, informing our final analytical plan. There were 116 free text comments about how 30-day mortality data might be misinterpreted (key themes: case-mix adjustment, inaccurate local coding, unfair penalty for low-volume units, data might discourage intervention in high-risk cases [risk aversion], and misinterpretation of crude mortality as a marker of procedure quality by the public or media).

## Institutional-level analysis

NHS trusts vary in size from single-site district general hospitals to larger organizations providing services on several sites. Unadjusted mortality was plotted against case volume in a funnel plot for each year, with confidence limits around the national mean (Fig. 1A and B). Without

case-mix adjustment, we observed a typical funnel-shaped distribution. No trust lay outside the outer 99.8% binomial confidence limit in any data year, nor did any single trust occupy a position outside the 95% limit in both data years. Regression analysis showed no significant trend between procedure volume and all-cause 30-day mortality ($r$ = -0.05; $P > .05$; n = 150 trusts).

By using the national-level pooled analysis as reference (Table 4), we calculated expected deaths according to local case-mix for each trust based on age groups, admission status, cancer diagnosis, and the comorbidity variable and produced standardized rates. The unadjusted (Fig. 1C) and case-mix adjusted rates were plotted (Fig. 1D). As with the unadjusted crude rates, the case-mix adjusted data showed a typical funnel-shape, with all trusts lying within the arbitrary outer statistical confidence limits.

## DISCUSSION

This study describes a national linkage analysis of all-cause mortality in patients undergoing first ERCP and the relative influence of simple demographic and clinical variables. Published data on 30-day mortality after ERCP for unselected national samples are limited, although a recent Swedish registry project reported a rate of 5.9% (n = 8088 patients; malignancy in 10.3%).[21] This figure is very similar to our finding of 5.3% (n = 40,938 patients; malignancy in 15%).

Study strengths include nationwide coverage (all English NHS hospitals) rather than selected or volunteer units.[2,5,20] Routine coding of hospital episodes occurs irrespective of case severity or outcome and should yield an unbiased population. Mortality status was established by linkage to the national death registry—the most accurate record of alive-dead status available with the added advantage of capturing death outside of hospitals (eg, at home or hospices). Uniquely, our study benefited from feedback gained from sharing routine data with local teams. By using clinical feedback, we developed algorithms for the grouping of primary and lower order diagnoses into relevant diagnostic categories, linked data on individual patients to focus on first (rather than repeat) procedures, and tracked readmissions to identify last-coded diagnoses before death.

Weaknesses relate mainly to a paucity of clinical detail within HES data and issues of incomplete local coding and/or variation in coding quality. Although legitimate concerns remain about coding accuracy, a number of incentives have driven improvements in NHS coding in recent years.[22] The case mix observed in the present study was very similar to that of a prospective United Kingdom survey[5] and total ERCP volume recorded in the HES dataset (about 40,000 ERCPs per annum in England) is compatible with earlier independent estimates of national ERCP demand.[23]

Mortality after ERCP is explained largely by the natural history of underlying disease. Most early deaths occur in older, emergency patients with comorbid conditions and underlying cancer. Palliation of malignancy is a key indication for ERCP, and short-term prognosis is often poor. Our real-world estimates of relatively high 30-day mortality for such cases should not necessarily deter intervention—even in the highest-risk groups the majority of cases survive. Our look-up table provides a basis for a better-informed, more individualized discussion of risk and prognosis.

Our institutional-level analysis yielded a funnel-shaped distribution of 30-day mortality, both before and after simple case-mix adjustment. This suggests a process under control, with variation likely to reflect common-cause factors (eg, differing case severity and complexity) that cannot be determined reliably from routine coding. We did not find a correlation between all-cause mortality and procedure volume for first ERCPs, in agreement with an American database study of inpatient ERCPs.[24]

Monitoring of mortality has been advocated as a performance indicator for procedures that have significant procedure-related mortality.[9] Although the headline mortality risk of 5% after ERCP might suggest a potential for institutional comparisons, the very low rate of mortality among cases lacking risk factors for disease progression suggests a very low signal-to-noise ratio. The relatively narrow scatter of all-cause mortality across units in England is reassuring for patients, but very few deaths are likely to be procedure related. Specific codes relating to possible technical complications of ERCP were recorded in only 1.2% of deaths (just 0.06% of total procedures, as reported in a single-center U.S. study).[20] Analysis of routine coding does not allow distinction between disease progression (eg, pneumonia related to cancer) and specific postprocedure complications (eg, aspiration pneumonia after ERCP).

The development of performance indicators is a growing industry within health care, but institutional comparisons of crude mortality statistics require great care. As an index of the quality of ERCP operator performance, the value of crude 30-day mortality statistics is doubtful, and better measures are needed.[25] Nevertheless, in the setting of the United Kingdom NHS, linkage analysis of routine administrative data to registry of death offers a potentially powerful tool for studying real-world mortality after endoscopic procedures on a genuinely national basis.

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## 7.5. Additional Data Tables

Table A3.1 Table showing Trusts that contributed to the BSG ERCP audit and how many cases each Trust entered

| Trust Code | Trust Name | Number of procedures entered into BSG audit from each TRUST |
|---|---|---|
| RAL | ROYAL FREE HAMPSTEAD NHS TRUST | 100 |
| RBL | WIRRAL UNIVERSITY TEACHING HOSPITAL NHS FOUNDATION TRUST | 99 |
| RBN | ST HELENS AND KNOWSLEY HOSPITALS NHS TRUST | 54 |
| RDD | BASILDON AND THURROCK UNIVERSITY HOSPITALS NHS FOUNDATION TRUST | 147 |
| RDE | COLCHESTER HOSPITAL UNIVERSITY NHS FOUNDATION TRUST | 54 |
| REM | AINTREE UNIVERSITY HOSPITALS NHS FOUNDATION TRUST | 12 |
| RF4 | BARKING, HAVERING AND REDBRIDGE HOSPITALS NHS TRUST | 83 |
| RFS | CHESTERFIELD ROYAL HOSPITAL NHS FOUNDATION TRUST | 74 |
| RFW | WEST MIDDLESEX UNIVERSITY HOSPITAL NHS TRUST | 39 |
| RG2 | QUEEN ELIZABETH HOSPITAL NHS TRUST | 82 |
| RG3 | BROMLEY HOSPITALS NHS TRUST | 97 |
| RJ1 | GUY'S AND ST THOMAS' NHS FOUNDATION TRUST | 249 |
| RJ2 | THE LEWISHAM HOSPITAL NHS TRUST | 54 |
| RJC | SOUTH WARWICKSHIRE GENERAL HOSPITALS NHS TRUST | 59 |
| RJN | EAST CHESHIRE NHS TRUST | 36 |
| RKB | UNIVERSITY HOSPITALS COVENTRY AND WARWICKSHIRE NHS TRUST | 152 |
| RL4 | THE ROYAL WOLVERHAMPTON HOSPITALS NHS TRUST | 81 |
| RLQ | HEREFORD HOSPITALS NHS TRUST | 30 |
| RLT | GEORGE ELIOT HOSPITAL NHS TRUST | 31 |
| RM2 | UNIVERSITY HOSPITAL OF SOUTH MANCHESTER NHS FOUNDATION TRUST | 186 |
| RM3 | SALFORD ROYAL NHS FOUNDATION TRUST | 57 |
| RMC | BOLTON HOSPITALS NHS TRUST | 37 |
| RMP | TAMESIDE HOSPITAL NHS FOUNDATION TRUST | 55 |
| RN7 | DARTFORD AND GRAVESHAM NHS TRUST | 127 |
| RNA | DUDLEY GROUP OF HOSPITALS NHS TRUST | 235 |
| RNJ | BARTS AND THE LONDON NHS TRUST | 79 |
| RP5 | DONCASTER AND BASSETLAW HOSPITALS NHS FOUNDATION TRUST | 93 |
| RQ6 | ROYAL LIVERPOOL AND BROADGREEN UNIVERSITY HOSPITALS NHS TRUST | 292 |
| RQ8 | MID ESSEX HOSPITAL SERVICES NHS TRUST | 74 |

| | | |
|---|---|---|
| RQM | CHELSEA AND WESTMINSTER HOSPITAL NHS FOUNDATION TRUST | 216 |
| RR1 | HEART OF ENGLAND NHS FOUNDATION TRUST | 103 |
| RRK | UNIVERSITY HOSPITAL BIRMINGHAM NHS FOUNDATION TRUST | 137 |
| RTG | DERBY HOSPITALS NHS FOUNDATION TRUST | 38 |
| RV8 | NORTH WEST LONDON HOSPITALS NHS TRUST | 93 |
| RVV | EAST KENT HOSPITALS UNIVERSITY NHS TRUST | 170 |
| RVY | SOUTHPORT AND ORMSKIRK HOSPITAL NHS TRUST | 24 |
| RW3 | CENTRAL MANCHESTER AND MANCHESTER CHILDREN'S UNIVERSITY HOSPITALS NHS TRUST | 65 |
| RW6 | PENNINE ACUTE HOSPITALS NHS TRUST | 137 |
| RWE | UNIVERSITY HOSPITALS OF LEICESTER NHS TRUST | 84 |
| RWF | MAIDSTONE AND TUNBRIDGE WELLS NHS TRUST | 24 |
| RWG | WEST HERTFORDSHIRE HOSPITALS NHS TRUST | 73 |
| RWH | EAST AND NORTH HERTFORDSHIRE NHS TRUST | 126 |
| RWJ | STOCKPORT NHS FOUNDATION TRUST | 145 |
| RWP | WORCESTERSHIRE ACUTE HOSPITALS NHS TRUST | 49 |
| RX1 | NOTTINGHAM UNIVERSITY HOSPITALS NHS TRUST | 242 |
| RXC | EAST SUSSEX HOSPITALS NHS TRUST | 77 |
| RXH | BRIGHTON AND SUSSEX UNIVERSITY HOSPITALS NHS TRUST | 77 |
| RXK | SANDWELL AND WEST BIRMINGHAM HOSPITALS NHS TRUST | 52 |
| RXN | LANCASHIRE TEACHING HOSPITALS NHS FOUNDATION TRUST | 44 |
| RXR | EAST LANCASHIRE HOSPITALS NHS TRUST | 98 |
| RXW | SHREWSBURY AND TELFORD HOSPITAL NHS TRUST | 105 |

***Table A5.1 Comparison of raw data from Sentinel stroke audit 2008 and HES analysis***

| Trust | SINAP swallow score (%) 2008 | SINAP average all 9 indicators (%) 2008 | SINAP swallow rank (1=lowest score; 115=highest) | SINAP average rank overall (1=lowest score; 115=highest) | SINAP average score tertile (1=worst; 3=best) | SINAP swallow score tertile (1=worst; 3=best) | HES data PEG7DM (%) 2008 | HES data PEG7DM RANK (1=highest mortality; 115 = lowest) |
|---|---|---|---|---|---|---|---|---|
| Gateshead health NHS foundation trust | 83.0 | 65.6 | 82 | 37 | 1 | 3 | 33.3 | 1 |
| Worcestershire acute hospitals NHS trust | 23.5 | 40.5 | 1 | 1 | 1 | 1 | 27.3 | 2 |
| Homerton university hospital NHS foundation trust | 68.0 | 84.3 | 39 | 100 | 3 | 2 | 25.0 | 3 |
| United Lincolnshire hospitals NHS trust | 68.3 | 63.2 | 44 | 29 | 1 | 2 | 23.1 | 4 |
| Barnsley hospital NHS foundation trust | 88.0 | 74.1 | 91 | 63 | 2 | 3 | 22.2 | 5 |
| Northern Lincolnshire and Goole hospitals NHS foundation trust | 62.0 | 60.4 | 29 | 19 | 1 | 1 | 22.2 | 6 |
| Dudley group of hospitals NHS trust | 98.0 | 78.0 | 108 | 76 | 2 | 3 | 21.4 | 7 |
| Ealing hospital NHS trust | 100.0 | 70.2 | 113 | 54 | 2 | 3 | 20.0 | 8 |
| Bedford hospital NHS trust | 62.0 | 60.3 | 30 | 18 | 1 | 1 | 20.0 | 9 |
| Southport and Ormskirk hospital NHS trust | 82.0 | 75.2 | 79 | 67 | 2 | 3 | 16.7 | 10 |
| Wirral university teaching hospital NHS foundation trust | 100.0 | 85.6 | 114 | 102 | 3 | 3 | 16.7 | 11 |
| Kingston hospital NHS trust | 76.0 | 80.4 | 64 | 83 | 3 | 2 | 16.7 | 12 |
| Isle of Wight | 81.0 | 64.4 | 73 | 33 | 1 | 2 | 16.7 | 13 |
| Mid Essex hospital services NHS trust | 67.0 | 67.7 | 37 | 43 | 2 | 1 | 16.7 | 14 |
| Bolton hospitals NHS trust | 86.0 | 92.0 | 89 | 113 | 3 | 3 | 16.1 | 15 |
| Central Manchester and Manchester children's university hospitals NHS trust | 37.0 | 59.6 | 3 | 15 | 1 | 1 | 15.4 | 16 |
| Aintree university hospitals NHS foundation trust | 98.0 | 83.6 | 109 | 97 | 3 | 3 | 15.4 | 17 |

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|---|---|---|---|---|---|---|---|---|
| Buckinghamshire hospitals NHS trust | 58.0 | 65.1 | 20 | 35 | 1 | 1 | 15.4 | 18 |
| Peterborough and Stamford hospitals NHS foundation trust | 90.0 | 76.7 | 96 | 72 | 2 | 3 | 15.4 | 19 |
| The Queen Elizabeth Hospital King's Lynn NHS trust | 50.0 | 74.3 | 11 | 65 | 2 | 1 | 15.4 | 20 |
| Northampton general hospital NHS trust | 56.0 | 68.4 | 17 | 45 | 2 | 1 | 14.3 | 21 |
| Chesterfield royal hospital NHS foundation trust | 70.0 | 68.8 | 49 | 46 | 2 | 2 | 14.3 | 22 |
| St George's healthcare NHS trust | 83.0 | 88.7 | 83 | 111 | 3 | 3 | 14.3 | 23 |
| The Lewisham hospital NHS trust | 94.0 | 82.3 | 104 | 95 | 3 | 3 | 14.3 | 24 |
| Mid Staffordshire NHS foundation trust | 69.0 | 62.1 | 46 | 27 | 1 | 2 | 14.3 | 25 |
| South Warwickshire general hospitals NHS trust | 64.0 | 61.6 | 33 | 25 | 1 | 1 | 14.3 | 26 |
| Sheffield teaching hospitals NHS foundation trust | 82.0 | 76.9 | 80 | 74 | 2 | 3 | 13.3 | 27 |
| Royal Cornwall hospitals NHS trust | 60.0 | 50.7 | 26 | 3 | 1 | 1 | 12.5 | 28 |
| Milton Keynes hospital NHS foundation trust | 89.0 | 82.1 | 93 | 93 | 3 | 3 | 12.5 | 29 |
| York hospitals NHS foundation trust | 81.0 | 69.9 | 74 | 53 | 2 | 2 | 12.5 | 30 |
| Walsall hospitals NHS trust | 58.0 | 69.2 | 21 | 49 | 2 | 1 | 11.1 | 31 |
| Bromley hospitals NHS trust | 54.0 | 56.7 | 15 | 11 | 1 | 1 | 10.0 | 32 |
| Colchester hospital university NHS foundation trust | 59.0 | 69.4 | 25 | 51 | 2 | 1 | 10.0 | 33 |
| Brighton and Sussex university hospitals NHS trust | 93.0 | 79.7 | 101 | 81 | 3 | 3 | 10.0 | 34 |
| Sherwood forest hospitals NHS foundation trust | 74.0 | 66.0 | 59 | 38 | 1 | 2 | 10.0 | 35 |
| Mid Cheshire hospitals NHS foundation trust | 45.0 | 42.3 | 8 | 2 | 1 | 1 | 9.1 | 36 |
| Epsom and St Helier university hospitals NHS trust | 62.0 | 68.4 | 31 | 44 | 2 | 1 | 9.1 | 37 |
| Sandwell and west Birmingham hospitals NHS trust | 81.5 | 69.1 | 78 | 48 | 2 | 3 | 8.8 | 38 |
| Harrogate and district NHS foundation trust | 91.0 | 89.1 | 99 | 112 | 3 | 3 | 8.3 | 39 |

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|---|---|---|---|---|---|---|---|---|
| West Suffolk hospitals NHS trust | 69.0 | 67.6 | 47 | 42 | 2 | 2 | 8.3 | 40 |
| Kettering general hospital NHS trust | 49.0 | 53.9 | 9 | 9 | 1 | 1 | 8.0 | 41 |
| County Durham and Darlington NHS foundation trust | 60.5 | 61.9 | 27 | 26 | 1 | 1 | 7.7 | 42 |
| Heatherwood and Wexham park hospitals NHS foundation trust | 55.0 | 53.8 | 16 | 8 | 1 | 1 | 7.7 | 43 |
| ROYAL WEST SUSSEX NHS TRUST (Now Western Sussex hospitals) | 92.0 | 73.1 | 100 | 58 | 2 | 3 | 7.7 | 44 |
| North Cumbria university hospitals NHS trust | 73.0 | 74.9 | 55 | 66 | 2 | 2 | 7.1 | 45 |
| Hull and east Yorkshire hospitals NHS trust | 98.0 | 86.3 | 110 | 106 | 3 | 3 | 7.1 | 46 |
| NORTH CHESHIRE HOSPITALS NHS TRUST (Warrington and Halton NHS Trust) | 65.0 | 76.9 | 36 | 73 | 2 | 1 | 6.7 | 47 |
| George Eliot hospital NHS trust | 84.0 | 69.4 | 86 | 52 | 2 | 3 | 5.9 | 48 |
| Royal free Hampstead NHS trust | 100.0 | 96.1 | 115 | 114 | 3 | 3 | 5.9 | 49 |
| Mid Yorkshire hospitals NHS trust | 58.0 | 56.7 | 22 | 12 | 1 | 1 | 5.6 | 50 |
| The royal Wolverhampton hospitals NHS trust | 69.0 | 73.2 | 48 | 59 | 2 | 2 | 5.6 | 51 |
| Derby hospitals NHS foundation trust | 68.0 | 82.1 | 40 | 94 | 3 | 2 | 5.4 | 52 |
| North Bristol NHS trust | 82.0 | 74.1 | 81 | 62 | 2 | 3 | 5.3 | 53 |
| Calderdale and Huddersfield NHS foundation trust | 49.0 | 63.6 | 10 | 30 | 1 | 1 | 4.8 | 54 |
| Shrewsbury and tenfold hospital NHS trust | 42.0 | 59.6 | 6 | 16 | 1 | 1 | 4.8 | 55 |
| Oxford Radcliffe hospitals NHS trust | 25.5 | 51.8 | 2 | 6 | 1 | 1 | 3.8 | 56 |
| University hospitals Coventry and Warwickshire NHS trust | 74.0 | 79.9 | 60 | 82 | 3 | 2 | 3.7 | 57 |
| Salford royal NHS foundation trust | 90.0 | 88.6 | 97 | 110 | 3 | 3 | 3.3 | 58 |
| Pennine acute hospitals NHS trust | 85.2 | 81.7 | 88 | 91 | 3 | 3 | 2.6 | 59 |
| Norfolk and Norwich university hospitals NHS foundation trust | 39.0 | 56.6 | 4 | 10 | 1 | 1 | 2.6 | 60 |
| Blackpool, Fylde and Wyre hospitals NHS foundation trust | 50.0 | 60.6 | 12 | 21 | 1 | 1 | 0.0 | 61 |

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|---|---|---|---|---|---|---|---|---|
| Burton hospitals NHS trust | 52.0 | 66.7 | 14 | 39 | 2 | 1 | 0.0 | 62 |
| Plymouth hospitals NHS trust | 57.0 | 61.1 | 19 | 23 | 1 | 1 | 0.0 | 63 |
| Lancashire teaching hospitals NHS foundation trust | 58.0 | 51.0 | 23 | 4 | 1 | 1 | 0.0 | 64 |
| The princess Alexandra hospital NHS trust | 64.0 | 63.0 | 34 | 28 | 1 | 1 | 0.0 | 65 |
| Bradford teaching hospitals NHS foundation trust | 68.0 | 63.7 | 41 | 31 | 1 | 2 | 0.0 | 66 |
| Royal Devon and Exeter NHS foundation trust | 64.0 | 82.9 | 35 | 96 | 3 | 1 | 0.0 | 67 |
| East Lancashire hospitals NHS trust | 72.0 | 60.6 | 53 | 20 | 1 | 2 | 0.0 | 68 |
| East Sussex hospitals NHS trust | 68.0 | 73.7 | 42 | 60 | 2 | 2 | 0.0 | 69 |
| Barnet and chase farm hospitals NHS trust | 72.0 | 76.9 | 54 | 75 | 2 | 2 | 0.0 | 70 |
| South tees hospitals NHS trust | 73.5 | 76.0 | 58 | 68 | 2 | 2 | 0.0 | 71 |
| Wrightington, Wigan and Leigh NHS trust | 74.0 | 81.1 | 61 | 88 | 3 | 2 | 0.0 | 72 |
| The Newcastle upon Tyne hospitals NHS foundation trust | 78.0 | 73.0 | 68 | 57 | 2 | 2 | 0.0 | 73 |
| Ashford and St Peter's hospitals NHS trust | 79.0 | 76.0 | 70 | 69 | 2 | 2 | 0.0 | 74 |
| Barking, Havering and Redbridge hospitals NHS trust | 80.5 | 80.8 | 72 | 86 | 3 | 2 | 0.0 | 75 |
| Tameside hospital NHS foundation trust | 81.0 | 76.1 | 75 | 70 | 2 | 2 | 0.0 | 76 |
| Countess of Chester hospital NHS foundation trust | 83.0 | 79.0 | 84 | 78 | 3 | 3 | 0.0 | 77 |
| Royal surrey county hospital NHS trust | 76.0 | 85.2 | 65 | 101 | 3 | 2 | 0.0 | 78 |
| North west London hospitals NHS trust | 85.0 | 79.3 | 87 | 80 | 3 | 3 | 0.0 | 79 |
| Royal Liverpool and Broadgreen university hospitals NHS trust | 88.0 | 83.6 | 92 | 98 | 3 | 3 | 0.0 | 80 |
| Imperial college healthcare NHS trust | 89.0 | 86.0 | 94 | 104 | 3 | 3 | 0.0 | 81 |
| Northumbria healthcare NHS foundation trust | 90.0 | 86.2 | 98 | 105 | 3 | 3 | 0.0 | 82 |
| South Devon healthcare NHS foundation trust | 93.0 | 85.7 | 102 | 103 | 3 | 3 | 0.0 | 83 |

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|---|---|---|---|---|---|---|---|---|
| Royal Berkshire NHS foundation trust | 95.0 | 81.3 | 105 | 90 | 3 | 3 | 0.0 | 84 |
| South end university hospital NHS foundation trust | 96.0 | 88.6 | 107 | 109 | 3 | 3 | 0.0 | 85 |
| King's college hospital NHS foundation trust | 98.0 | 97.6 | 111 | 115 | 3 | 3 | 0.0 | 86 |
| North Middlesex university hospital NHS trust | 86.0 | 78.4 | 90 | 77 | 2 | 3 | 0.0 | 87 |
| QUEEN ELIZABETH HOSPITAL NHS TRUST (now RG3 - Bromley) | 50.0 | 58.0 | 13 | 14 | 1 | 1 | 0.0 | 88 |
| QUEEN MARY'S SIDCUP NHS TRUST (now RG3 - Bromley) | 63.0 | 53.3 | 32 | 7 | 1 | 1 | 0.0 | 89 |
| The Whittington hospital NHS trust | 68.0 | 88.1 | 43 | 108 | 3 | 2 | 0.0 | 90 |
| West Middlesex university hospital NHS trust | 83.0 | 79.2 | 85 | 79 | 3 | 3 | 0.0 | 91 |
| Whipps cross university hospital NHS trust | 75.0 | 80.9 | 62 | 87 | 3 | 2 | 0.0 | 92 |
| Cambridge university hospitals NHS foundation trust | 70.0 | 80.8 | 50 | 85 | 3 | 2 | 0.0 | 93 |
| Dartford and Gravesham NHS trust | 58.0 | 65.1 | 24 | 36 | 1 | 1 | 0.0 | 94 |
| Doncaster and Bassetlaw hospitals NHS foundation trust | 41.0 | 74.2 | 5 | 64 | 2 | 1 | 0.0 | 95 |
| East Kent hospitals university NHS trust | 93.0 | 82.0 | 103 | 92 | 3 | 3 | 0.0 | 96 |
| Heart of England NHS foundation trust | 70.5 | 71.1 | 52 | 56 | 2 | 2 | 0.0 | 97 |
| Ipswich hospital NHS trust | 73.0 | 61.1 | 56 | 22 | 1 | 2 | 0.0 | 98 |
| James Paget university hospitals NHS foundation trust | 43.0 | 67.1 | 7 | 41 | 2 | 1 | 0.0 | 99 |
| Leeds teaching hospitals NHS trust | 81.0 | 64.0 | 76 | 32 | 1 | 2 | 0.0 | 100 |
| Luton and Dunstable hospital NHS foundation trust | 79.0 | 64.7 | 71 | 34 | 1 | 2 | 0.0 | 101 |
| Maidstone and Tunbridge wells NHS trust | 61.5 | 61.3 | 28 | 24 | 1 | 1 | 0.0 | 102 |
| North tees and Hartlepool NHS foundation trust | 78.0 | 84.3 | 69 | 99 | 3 | 2 | 0.0 | 103 |
| Nottingham university hospitals NHS trust | 73.0 | 68.8 | 57 | 47 | 2 | 2 | 0.0 | 104 |
| Poole hospital NHS foundation trust | 89.0 | 74.0 | 95 | 61 | 2 | 3 | 0.0 | 105 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Portsmouth hospitals NHS trust | 70.0 | 57.8 | 51 | 13 | 1 | 2 | 0.0 | 106 |
| Royal united hospital bath NHS trust | 77.0 | 70.6 | 67 | 55 | 2 | 2 | 0.0 | 107 |
| Southampton university hospitals NHS trust | 76.0 | 76.7 | 66 | 71 | 2 | 2 | 0.0 | 108 |
| The Rotherham NHS foundation trust | 75.0 | 80.4 | 63 | 84 | 3 | 2 | 0.0 | 109 |
| University hospital Birmingham NHS foundation trust | 67.0 | 66.9 | 38 | 40 | 2 | 1 | 0.0 | 110 |
| University hospitals of Leicester NHS trust | 81.0 | 69.3 | 77 | 50 | 2 | 2 | 0.0 | 111 |
| University hospitals of Morecambe bay NHS trust | 68.7 | 59.9 | 45 | 17 | 1 | 2 | 0.0 | 112 |
| West Hertfordshire hospitals NHS trust | 95.0 | 81.2 | 106 | 89 | 3 | 3 | 0.0 | 113 |
| Weston area health NHS trust | 56.0 | 51.2 | 18 | 5 | 1 | 1 | 0.0 | 114 |
| Winchester and Eastleigh healthcare NHS trust | 98.0 | 86.3 | 112 | 107 | 3 | 3 | 0.0 | 115 |

Table A5.2 Comparison of numbers of stroke patients from Sentinel stroke audit 2008 and HES analysis

| Trust | SINAP Total strokes for 3m | SINAP Total strokes for 12m (historical data) | Our Total strokes for 12m | Our total divided by 4 |
|---|---|---|---|---|
| | SINAP data | | Our data | |
| King's College Hospital NHS Foundation Trust | 219 | 151 | 474 | 119 |
| Imperial College Healthcare NHS Trust | 224 | 294 | 810 | 203 |
| Northumbria Healthcare NHS Foundation Trust | 24 | 497 | 974 | 244 |
| Salford Royal NHS Foundation Trust | 103 | 871 | 529 | 132 |
| St George's Healthcare NHS Trust | 302 | 967 | 634 | 159 |
| South Tees Hospitals NHS Trust | 93 | 288 | 915 | 229 |
| Aintree University Hospitals NHS Foundation Trust | 115 | 486 | 547 | 137 |
| The Newcastle Upon Tyne Hospitals NHS Foundation Trust | 48 | 18 | 887 | 222 |
| Royal Liverpool And Broadgreen University Hospitals NHS Trust | 132 | 308 | 586 | 147 |
| North West London Hospitals NHS Trust | 225 | 255 | 602 | 151 |
| Barking, Havering And Redbridge Hospitals NHS Trust | 181 | 10 | 999 | 250 |
| Southend University Hospital NHS Foundation Trust | 99 | 86 | 638 | 160 |
| Royal Berkshire NHS Foundation Trust | 182 | 289 | 595 | 149 |
| Blackpool, Fylde And Wyre Hospitals NHS Foundation Trust | 77 | 216 | 676 | 169 |
| The Princess Alexandra Hospital NHS Trust | 39 | 0 | 349 | 87 |
| Chesterfield Royal Hospital NHS Foundation Trust | 82 | 276 | 510 | 128 |
| Wirral University Teaching Hospital NHS Foundation Trust | 163 | 351 | 827 | 207 |
| Hull And East Yorkshire Hospitals NHS Trust | 56 | 55 | 1018 | 255 |
| Ashford And St Peter's Hospitals NHS Trust | 100 | 147 | 532 | 133 |
| Gateshead Health NHS Foundation Trust | 60 | 254 | 475 | 119 |
| Northampton General Hospital NHS Trust | 171 | 437 | 453 | 113 |
| Colchester Hospital University NHS Foundation Trust | 32 | 52 | 640 | 160 |
| Lancashire Teaching Hospitals NHS Foundation Trust | 95 | 233 | 693 | 173 |
| Royal Devon And Exeter NHS Foundation Trust | 75 | 58 | 673 | 168 |
| North Cumbria University Hospitals NHS Trust | 64 | 419 | 636 | 159 |
| Royal Surrey County Hospital NHS Trust | 79 | 10 | 355 | 89 |
| Wrightington, Wigan And Leigh NHS Trust | 53 | 306 | 619 | 155 |
| Sheffield Teaching Hospitals NHS Foundation Trust | 225 | 135 | 1206 | 302 |
| East Lancashire Hospitals NHS Trust | 70 | 69 | 893 | 223 |
| Pennine Acute Hospitals NHS Trust | 57 | 891 | 1577 | 394 |

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|---|---|---|---|---|
| **Southport And Ormskirk Hospital NHS Trust** | 87 | 301 | 434 | 109 |
| **East Sussex Hospitals NHS Trust** | 20 | 202 | 846 | 212 |
| **Bromley Hospitals NHS Trust** | 31 | no data available | 362 | 91 |
| **South Devon Healthcare NHS Foundation Trust** | 89 | 563 | 702 | 176 |
| **George Eliot Hospital NHS Trust** | 22 | 49 | 310 | 78 |
| **Oxford Radcliffe Hospitals NHS Trust** | 46 | 5 | 868 | 217 |
| **Countess Of Chester Hospital NHS Foundation Trust** | 38 | 245 | 386 | 97 |
| **Mid Cheshire Hospitals NHS Foundation Trust** | 73 | 339 | 413 | 103 |
| **Tameside Hospital NHS Foundation Trust** | 64 | 331 | 399 | 100 |
| **Worcestershire Acute Hospitals NHS Trust** | 54 | 117 | 897 | 224 |
| **Barnet And Chase Farm Hospitals NHS Trust** | 21 | | 640 | 160 |
| **Bolton Hospitals NHS Trust** | 45 | 376 | 562 | 141 |
| **Burton Hospitals NHS Trust** | 65 | 209 | 275 | 69 |
| **Central Manchester And Manchester Children's University Hospitals NHS Trust** | 46 | 241 | 373 | 93 |
| **Kettering General Hospital NHS Trust** | 22 | 0 | 515 | 129 |
| **Bradford Teaching Hospitals NHS Foundation Trust** | 96 | 324 | 560 | 140 |
| **Plymouth Hospitals NHS Trust** | 24 | 0 | 755 | 189 |
| **Royal Cornwall Hospitals NHS Trust** | 142 | 800 | 914 | 229 |